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MODELING ORGANIZATIONAL CONFIGURATION AND DECISION PROCESSES FOR INFORMATION WARFARE ANALYSIS

by

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For an organization to survive it must be able to adapt to its environment. A military organization operates in an environment that is constantly changing. The ability to model organizational configurations and organizational decision processes can assist the commander in adapting to the environment and understanding how a military organization is susceptible to Information Warfare (IW) attacks. First a commander must understand the concepts of Information Warfare, Command and Control and the concept of organizational decision processes and how these permit an organization to adapt to its environment. Then the commander must determine what level of detail is necessary to model the organizational decision processes for its environment. Next the commander must analyze his model for configuration and decision processes. Using such commercially available software as *Organizational Consultant* and *VDT* the commander can identify any organizational misfits to the environment and the IW attack susceptibilities of the organizational decision processes. In the end, this approach demonstrates that it is feasible to model organizational configuration and organizational decision processes in an Information Warfare environment.

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MODELING ORGANIZATIONAL CONFIGURATION AND DECISION PROCESSES FOR INFORMATION WARFARE ANALYSIS

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ABSTRACT

For an organization to survive it must be able to adapt to its environment. A military organization operates in an environment that is constantly changing. The ability to model organizational configurations and organizational decision processes can assist the commander in adapting to the environment and understanding how a military organization is susceptible to Information Warfare (IW) attacks. First a commander must understand the concepts of Information Warfare, Command and Control and the concept of organizational decision processes and how these permit an organization to adapt to its environment. Then the commander must determine what level of detail is necessary to model the organizational decision processes for its environment. Next the commander must analyze his model for configuration and decision processes. Using such commercially available software as *Organizational Consultant* and *VDT* the commander can identify any organizational misfits to the environment and the IW attack susceptibilities of the organizational decision processes. In the end, this approach demonstrates that it is feasible to model organizational configuration and organizational decision processes in an Information Warfare environment.

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I. INTRODUCTION

A. PURPOSE OF THE THESIS

In this thesis the author examines modeling of organizational decision processes for the purpose of determining vulnerabilities to Information Warfare (IW). It is of particular importance because the ability to model organizational decision processes for susceptibilities to IW allows a commander to utilize scarce resources not only efficiently and effectively while attacking an opponent but also assists the commander in determining how best to utilize resources in an IW defense. If the Department of Defense (DoD) wants to capitalize on the ability of a commander to understand both one's own IW situation and also the opponent's IW situation, then the ability for a commander to model and test organizational decision processes must be developed and made available to the commander. In this thesis the author will explain the concept of IW, the concept of command and control (C2), the concept of organizational decision processes and how these processes permit an organization to adapt to its environment. Then the author will briefly look at what makes a good computer model for a simulation, how to model organizational decision processes for its environment and then how to model the organization for IW analysis.

The purpose of this investigation is the understanding of organizational configuration (structure) and organizational decision processes so that an assessment of the impact of IW on organizational performance can be made. The following three steps will lead to this understanding:

- Explain the general properties of organizational configuration, how an organization makes decisions (organizational decision properties), and how an organization adapts to its environment,
- Determine how to model an organization in its environment, and
- Determine how to model an organization to assess vulnerabilities to IW.

B. PRELIMINARIES

1. Definitions

The Department of Defense defines IW as "actions taken to achieve information superiority in support of national military strategy by affecting adversary information and information systems while leveraging and protecting our information and information systems." (OSD S-3600.1, 1996) Command and Control Warfare is defined as "the integrated use of operations security (OPSEC), Military deception, psychological operations (PSYOP), electronic warfare (EW), and physical destruction mutually supported by intelligence to deny information to, influence, degrade or destroy adversary command and control (C2) capabilities while protecting friendly C2 capabilities against such actions." (CJCS, 1993) An understanding of IW and C2W is essential to understanding how an organization is susceptible to IW attack. For further information discussing the basics of IW and C2W, LT Shawn James' thesis, entitled *Thinking Strategically About Information-Based Conflict: Developing an Analytical Approach to Operational Measures of Effectiveness*, is an excellent resource. (James, 1996)

2. Conventions

Organizational science is equally applicable to military and civilian organizations. That is, there is not a special branch of organizational science for military applications.

Therefore the understanding of organizational science developed in this thesis will apply equally to civilian and military applications alike. The example that is modeled is a Joint Task Force (JTF) organization. The reason it is chosen is because of some unique problems encountered by the commander of the JTF that was sent for humanitarian operations in Bangladesh and is well documented by Sessions and Jones (1996). The modeling technique is embodied in software, in particular the software used in this thesis, Organizational Consultant (Burton, 1995) and Virtual Design Team (Levitt, 1996) which is designed for the commercial sector but is applied in a military environment.

C. ORGANIZATION OF THE THESIS

This thesis is organized around the issues discussed earlier in Section A of this chapter. Chapter II introduces the reader to IW and C2 Warfare and includes the goals and elements of a C2 system and the Five Pillars of IW. Chapter III contains the discussion of what is meant by C2, and explains how an organization makes decisions, different types of organizational configurations and how an organization adapts to its environment. Chapter IV contains a brief survey of what a model should incorporate for investigating IW issues. Chapter V contains a scenario and then uses the *Organizational Consultant* software to determine the proper organizational configuration for an organization to achieve fit with its environment. Chapter VI takes the organizational configuration from Chapter V and uses the *Virtual Design Team* (VDT) software to investigate the organization for IW vulnerabilities. Finally, Chapter VII summarizes the thesis and contains suggestions for further research.

II. INFORMATION WARFARE

A. INTRODUCTION

As stated earlier The Department of Defense defines IW as "actions taken to achieve information superiority in support of national military strategy by affecting adversary information and information systems while leveraging and protecting our information and information systems." (OSD S-3600.1, 1996) If you reduce this definition to the essentials Information Warfare (IW) is attacking Command and Control (C2) nodes and links that physically support the decision making process. The entire decision making process consists of actors that are making decisions (nodes) and the input or output of those actors is the flow of information (links). The exploitation or protection of those nodes and links is the key to IW.

The C2 decision making process consists of the organizational configuration and decision making processes within the organization. For an organization to survive it must be in balance with its environment, hence it must be able to adapt to environmental changes. To accomplish organizational configuration design involves having a situation fit, a design parameter fit and total fit. (Burton, 1995, p. 10) Situation fit is based on the contingency factors for organizational structure: strategy, size/ownership, technology, environment and management preferences (i.e., the variables that relatively require a large amount of effort to change). Design parameter fit consists of the variables that are more easily manipulated and thus serve as excellent levers of change. These variables fall into two categories; structural configuration and properties. Total fit requires that the

design parameter recommendations fit together internally and that they also fit the actual situation. These three fits will be discussed at length in Chapter III. This adaptation is manifested in a "best fit" organizational configuration. The organizational decision making processes are driven by uncertainty and goal consensus by the decision makers. The way that an organizational decision process reaches a decision will be determined by the state of knowledge of the relationship between actions taken and their outcomes and the degree of concurrence by the decision makers about the goals or criteria for measuring performance.

This chapter will introduce IW and the Five Pillars that support an IW defense or that allow an IW attack. This chapter will also introduce C2W and explain what constitutes a C2W system.

B. INFORMATION WARFARE/COMMAND AND CONTROL WARFARE

1. Introduction

This section will define Information Warfare and C2 Warfare. It will also review the components that comprise a C2 system and their organization and susceptibilities. The Five Pillars of Information Warfare, which is the basis of any C2 defense or attack, also will be defined.

2. Information Warfare/Command and Control Warfare

It is difficult to have complete consensus on how IW and C2W are defined because the concepts are so new and there is yet no specific discipline dedicated to the concept. But for the purposes of this thesis it is defined as "Actions taken to achieve

information superiority by affecting adversary information, information based processes, information systems and computer-based networks while defending one's own information, information based processes, information systems and computer-based networks. C2 Warfare is a warfighting application of IW in military operations and is a subset of IW." (C2 Warfare, 1996, p. 1-3) The goal of C2 Warfare is to lead to "battlespace dominance" which is an asymmetrical flow of information between opponents in your favor. Information is the key, to both sides, and it is affected by the physical infrastructure.

a. Goals of Information Warfare/Command and Control Warfare

In its base form the goal of IW/C2W is to deny information to the enemy while maximizing friendly flow of information, this is also known as battlespace dominance. This is accomplished by denying information to the opponent, influence the opponent's decisions and actions by controlling what information the your opponent receives, and by degrading/destroying your opponent's information infrastructure.

b. Elements of a Command and Control System

All C2 systems in their base form consist of links and nodes. These links and nodes are comprised of personnel, equipment and procedures. Nodes are organized into systems and some systems are across multiple nodes. At first this definition might seem a bit obscure but that is exactly one of the challenges facing IW; that is, how exactly do you define IW. The important point is that the C2 system is viewed as links and nodes that can be exploited for IW purposes or that need to be defended for IW

purposes. This holistic approach allows for simple, rapid modeling and vulnerability analysis of a system.

c. *Two Types of Nodes and Links*

When examining a C2 system for exploitation or protection the initial reaction is to examine the nodes alone. While the nodes are where the information is processed and the decisions are made they are useless without the links. If the information can not flow then it has the same result as that of not being processed. The Iraqi army learned this during Desert Storm when their centralized command structure, manifested in Saddam Hussein, was denied all communications with the battlefield. Though the node (Saddam Hussein) was not destroyed, the links were and the result was the Iraqi army was without command. This example highlights the importance of both the nodes and the links and emphasizes the point that it is important to think of links as a special type of node, a node that exhibits information flow. For the purpose of this thesis nodes and links will be referred to as node/links because they are both susceptible to IW.

There are two types of node/links in a C2 systems, critical node/links and vulnerable node/links. A critical node/link is one where disruption or destruction has immediate effect on the C2. A vulnerable node/link is one where a node/link can be attacked and be subjected to manipulation and exploitation but does not have immediate effect upon the system. A vulnerable node/link must be susceptible there has to be some weakness that can be exploited), accessible (it must be reachable in some way) and feasible (the commander must be willing to sacrifice the resources necessary to exploit the node/link) to attack to be considered vulnerable. (C2, 1996, p. 4-5)

3. The Five Pillars of Information Warfare

a. Destruction

> IW destruction is the planned physical destruction of the opponents C2 node/links such that node/link can not function permanently or for a given period of time. Destruction, as with other elements of C2W, has two facets: destruction for C2-attack operations and destruction for C2-protect operations. (C2 Warfare, 1996, p. 11-3)

b. Electronic Warfare

> Any military action involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy. (C2 Warfare, 1996, p. 10-3)

There are three type of EW; electronic attack, electronic protection and electronic warfare support. Further information about these three types of EW can be found in *C2 Warfare* page 10-4.

c. Deception

> Military deception is defined as those actions executed to mislead foreign decision makers, causing them to derive and accept desired appreciations of military capabilities, intentions, operations or other activities that evoke foreign actions that contribute to the originators' objectives. (C2 Warfare, 1996, p. 9-3)

The essence of deception is to mislead an opponent by manipulation, distortion or falsification to force your opponent to act in a manner detrimental to the their best interests. While deception is an important part of any military operation it is important to remember that it is intended to support operations, not allow them.

d. Psychological Operations

> Psychological Operations (PSYOP) are planned operations involving the use of mass media techniques and/or actions to convey selected information and indicators to foreign audiences favorable to US national policy objectives to influence their attitudes, emotions, motives, objective reasoning and ultimately the behavior of the foreign

> government, organizations, groups and individuals. (C2 Warfare, 1996, p. 8-3)

One of the main arguments against PSYOP is that it is difficult to measure the marginal return of any PSYOP mission. As will be demonstrated later in the VDT model it is possible to measure the benefit of a PSYOP versus another attack using a different pillar and see the relative return for the same cost of the input attack.

e. Operations Security

> Operations Security (OPSEC) is defined as a process of identifying critical information and subsequently analyzing friendly actions attendant to military operations and other activities to : identify those actions that can be observed by adversary intelligence agencies, determine indicators adversary intelligence systems might obtain that could be interpreted or pieced together to derive critical information in time to be useful to adversaries, and select and execute measures that eliminate or reduce to an acceptable level the vulnerabilities of friendly actions to adversary exploitation. (C2 Warfare, 1996, p. 7-2)

Essentially OPSEC is concerned with identifying unclassified indicators (e.g., The North Vietnamese observing unclassified flight plans of B-52's filed in the international air traffic control system that detailed when and where they would enter North Vietnamese airspace) that could divulge friendly intentions.

4. The Target

The ultimate target of any IW attack is the opponent's decision making process, hence the decision makers. But in general the attack is against the physical infrastructure, which are any nodes or links in the C2 structure that are considered either a critical node/link or a vulnerable node/link.

In the author's opinion the Coalition Forces during Desert Storm proved this point remarkably. While the Iraqi decision maker, Saddam Hussein, was never a specific

target his command and control infrastructure was and the elimination of that infrastructure had the same consequence as the elimination of the decision maker.

C. CONCLUSION

As stated earlier node/links are the essential part of any C2W system and thus serve as an excellent focus of attack. The challenge is how best to attack the node/links. At first this might seem a trivial issue; elimination of the node/link and the commander has one less thing to worry about. This is not always the case. Much like a river flowing downstream the information will eventually find away to flow again (though it may be so late that it will do little good). Instead the issue of attack might be how to exploit the node/link to gain knowledge of the enemies intentions or how to alter the enemy's information to benefit the friendly forces. This is the area that the Five Pillars of IW can best be used. They allow an evaluation of the opponent's organization to determine the best marginal attack (i.e., the benefits of the attack vs. the cost of the attack). In Chapter VI the *VDT* software will be used to demonstrate this concept.

III. COMMAND AND CONTROL: THE INFORMATION WARFARE TARGET

The idea of C2W is as old as warfare itself. Destroying the adversary's capability to effectively command and control its forces is, and always has been a lucrative military target. Additionally, protecting friendly C2 has historically proven to be just as important to successful military operations. (C2, 1996, p. 1-2) While the study of C2W is a new phenomena only recently manifesting itself as a discipline the value of C2 as a "center of gravity" has been understood since the time of Clausewitz. The Coalition forces identified one of the Iraqi's significant weaknesses as a rigid, top-down C2 system and the reluctance of Iraqi commanders to exercise initiative. (DoD, 1992, p. 72) Exploitation of the Iraqi's centralized organization enabled the Coalition forces to obtain an asymmetrical flow of information which led to battlespace dominance. This chapter is going to introduce concepts for understanding C2 of military organizations, including C2 loops, C2 as organizational decision systems, C2 as organizational configuration, and C2 as organizational-environmental adaptation.

A. THE PHENOMENON: C2 OF MILITARY ORGANIZATIONS

1. Introduction

This section introduces the concept of C2, the Observe-Orient-Decide-Act (OODA) Loop, the Information Hierarchy, and how the OODA Loop and the Information Hierarchy form a generic functional model of C2 decision making processes. It also provides background into the drivers of organizational decision systems performance. In this section are three figures, the OODA Loop, the Information Hierarchy, and a

combination of the OODA Loop and the Information Hierarchy. They will illustrate that the C2 process is cyclical in nature and how the evaluation of data is used during the cycle.

2. Command and Control (C2)

Command, for military leaders, is having all the weapons systems, and people of the modern military and getting them to do what the commander wants. Control is diametrically opposed to this concept, it is getting them not to do what you don't want them to. (Haffner and Lyon, 1996, p. 54) Command and control is an area of important study that can produce numerous advantages to the commander that understands and implements it well. In this section C2 is defined and its implementation by the commander is explained.

a. Basic Definition

Command and Control is a relatively new discipline that has yet to have a universally accepted definition. About the only thing that can be agreed upon is that it is an important area of study and that it is an area of warfare that serves as a dramatic lever of change if used properly. These two points were learned well during Desert Storm when the Coalition forces were able to isolate the Iraqi army in the field from their centralized C2 structure with its apex in Baghdad. For the purpose of this thesis the author will use the Joint Chiefs of Staff (JCS) definition.

(1) JCS definition. The JCS definition of Command and Control is the exercise of authority and direction by a properly designated commander over assigned or attached forces in the accomplishment of the mission. C2 functions are

performed through an arrangement of personnel, equipment, communications, facilities and procedures employed by a commander in planning, directing, coordinating and controlling forces and operations in accomplishment of the mission. (Joint Pub 1-02)

(2) Putting the pieces together. Though the JCS definition does explain what C2 is it still does not explain who is responsible for C2 and what is to be accomplished by C2. Without this C2 is just another interesting buzzword that will serve little useful purpose. The burden of C2 rests with the commander alone for C2 encompasses all military functions and operations giving them significance and synergizing them into a meaningful whole. It brings the disparate pieces together and allows them to achieve what they could not achieve independently.

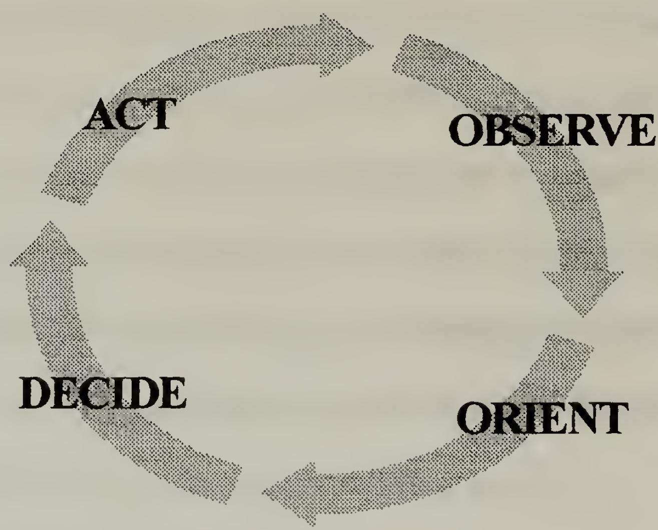
C2 is in essence the business of the Commander because he has the authority, both official authority and personal authority, and the responsibility. The commander recognizes what goals need to be achieved and sees to it that appropriate actions are taken to accomplish the mission. (Command and Control, circa. 1995, p. 21)

The goal of C2 is cohesion internal to the organization and adaptability externally. This goal can be achieved by using an organizational design that is adapted to its environment and has achieved a good total fit. Environmental adaptation and the concept of fit will be discussed later.

3. Nature of C2 Loops

There is a set of generic functions that needs to be performed in any C2 loop and they have to be performed in a certain order. An elementary example is identify the target, aim the weapon and fire. It is obvious that it would be a wasted effort to identify

the target, fire the weapon and then aim it. Following is an explanation of the OODA Loop and the Information Hierarchy and an illustration of how the two complement each other.



The Command and Control Process

Figure 1. OODA Loop. Source: Modeled after Figure 3 in the USMC Concept Paper, Command and Control

a. OODA Loop

Pictured above is a figure of the C2 cyclical process known as the OODA Loop. The OODA loop applies to any two sided conflict and is an acronym for Observe, Orient, Decide and Act which describes the basic sequence of events in the command and control cycle. Speed (effective speed) is important in the OODA loop for it is a cyclical process and with every iteration the antagonist who can cycle fastest gains an advantage.

(1) Observe. The first step in the OODA Loop is observation. In this step the Commander observes the situation by gathering information on opponent forces and his own forces and the environment that operations are to be conducted in.

(2) Orient. The second step in the OODA Loop is orientation by the commander. The commander achieves this by gathering information about the opponent and converting it into intelligence. This will enable a commander to fuse this knowledge with the knowledge of his own forces to make an assessment of the reality of the area of operations (AOR). The goal of the orientation phase is to develop a cohesive mental image of the situation.

(3) Decide. The third step in the OODA Loop is that of a decision where the commander, based upon his observations, will make a decision that is either an immediate reaction or a deliberate plan for future events.

(4) Act. The fourth step in the OODA Loop (but not the final step since it is a cyclical process) is action. The commanders decision is placed into action to include dissemination of the decision, to include ensuring proper execution of the decision by subordinates and monitoring the results via feedback.

The feedback is very important to the cycle for it serves as part of the Observe to start the cycle again. It is the bridge that keeps an effective cycle continuing.

b. Information Hierarchy

The Information Hierarchy consists of data in four different phases; raw data, processed data, knowledge and understanding. It illustrates the relative value of

data to the commander and what actions need to be performed to the data to advance it to a higher level in the hierarchy.

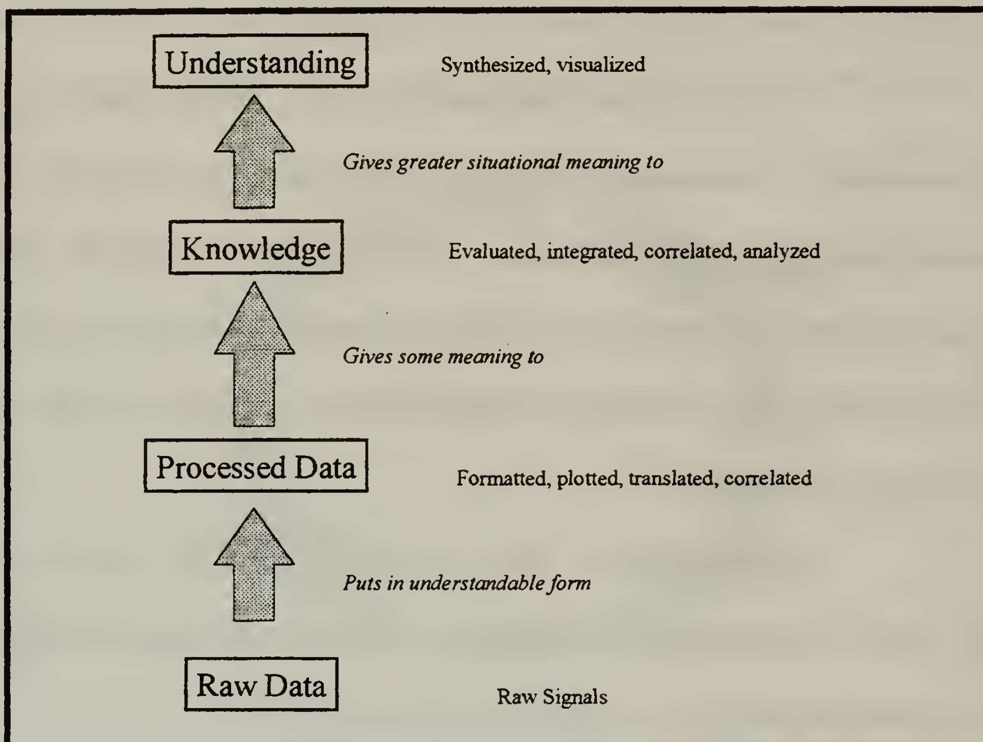


Figure 2. Information Hierarchy based on USMC Command and Control Paper, p. 46

(1) Raw Data. Raw data comprises the lowest class of data in the hierarchy to include unprocessed signals picked up by any sensor which could range from a photograph still on the unexposed film in the camera to an intercepted electronic message that has not been evaluated yet. This type of information has very little practical use other than to indicate that an event of some sort is taking place.

(2) Processed Data. Processed data is raw data that is "cooked" or processed into a useable form for the operators that will be evaluating the data. While processed data does have more value than raw data it is still of little use until it is analyzed. An example of processed data is film that is developed into pictures.

(3) Knowledge. Knowledge is processed data that has been analyzed and evaluated. An example of this is the processed picture that has been analyzed.

(4) Understanding. Understanding is knowledge that has been synthesized and applied to a given situation. An example of this is a series of processed pictures that have been analyzed and "data fused" to produce a complete picture of the event that is taking place.

c. *Generic Functional C2 Decision Process with Information Definitions*

Below is the OODA Loop integrated with the Information Hierarchy. It demonstrates at which points in the cyclical C2 decision process various forms of data are used. Raw data is data gathered for the commanders attention before it is processed, it represents namely that an event has occurred that requires his attention. The data is processed before the commander can observe it. Orientation and knowledge take place near simultaneously and they are based upon the processed data. Understanding takes place before the commander makes his decision as to what action will take place. After that action has taken place the results are evaluated and the input is raw data which begins the cycle again.

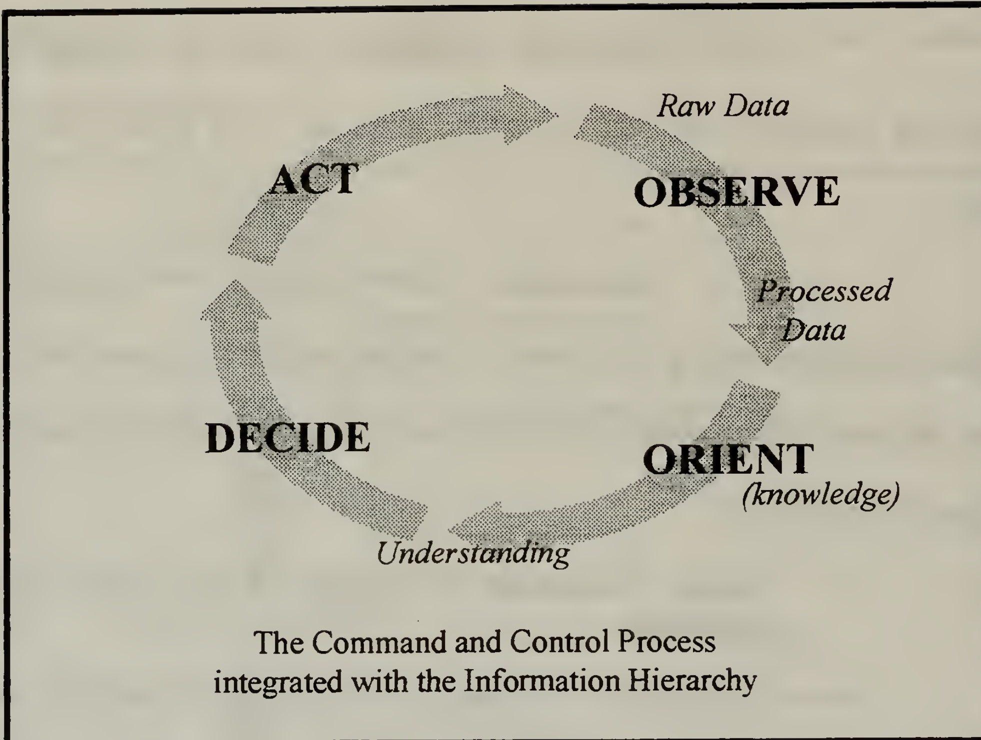


Figure 3. The OODA Loop integrated with the Information Hierarchy

d. Nested Loop

In any organization there are loops occurring within loops which are within more loops to the n^{th} degree. These layers of loops are referred to as nested loops and they consist of the OODA Loop-Information Hierarchy interaction detailed earlier. An example of a nested loop would be that of a platoon which experiences it own loop in its own encounters with the enemy. A company will have its own loop that will consist of the loops that are being experienced by the platoons in the company and an integrative loop at the company level. A battalion will have its own loop that will consist of the loops that are being experienced by the companies in the battalion and its own integrative loop and these nested loops will continue up through the entire chain of command.

The nested loops reflect the C2 process as the cyclical process that it is. The cycle constantly repeats through the Observe, Orient, Decide and Act loop. With

each cycle an evaluation is performed to see if the process needs to be adjusted in order to make it a more effective process. In the author's opinion it is important that the actors cycling through the loops farther up the "nest" be capable of a more rapid adaptation to their environment due to the fact than not only will the loop at their level effect their actions but also the actions of all of the actors at the lower levels, and since the cycles will be occurring at various frequencies, the actor farther up the chain will be presented with more data at inappropriate locations in the loop thus compressing the loop even more. To illustrate this point take a commander who is cycling through the OODA Loop and is currently poised to make a decision when suddenly he is given new knowledge from one of his subordinate commanders (who is also going through their own OODA Loops) and the commander has to make a decision; does he ignore the new knowledge and continue on with his previous cycle or does he abbreviate his cycle to go forward to the Orient phase thus increasing the speed of the cycle.

The actor who can cycle through the loop faster and effectively gains an advantage with each cycle. When the actor gains an advantage asymmetrical information flow is created (one actor is receiving more information from his opponent than the opponent is receiving from him). This asymmetrical information flow leads to battlespace dominance.

4. C2 as Organizational Decision Systems

The OODA Loop and the Information Hierarchy can deliver to the commander and the commander's staff useful information but it is the function of the staff and ultimately the commander to make the decision about what course of action needs to be

taken. This section will introduce different organizational decision making strategies, which are known as problem solving systems, based upon the amount of knowledge that exists between action and outcome and the degree of consensus about the goals by the decision makers. A problem solving system is defined as an interrelated set of decision makers focused on a specific problem and it means essentially the same thing as an organizational decision system.

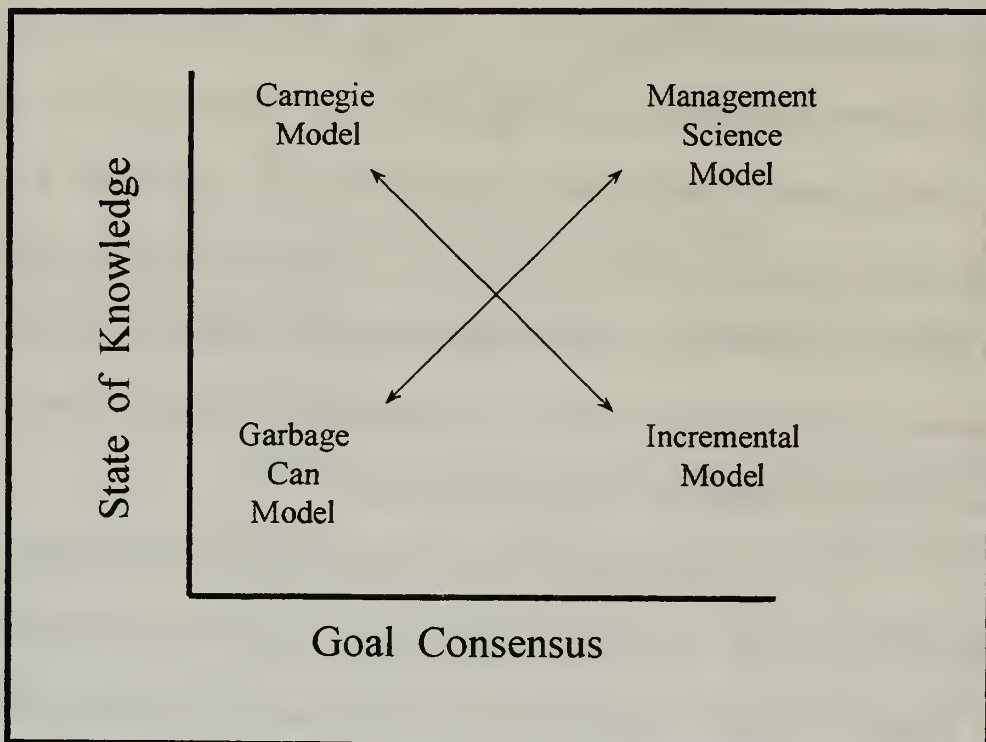


Figure 4. Problem Solving Systems

A problem solving system is driven by two major determinants: the state of knowledge of the relationship between action and outcome, and the degree of consensus about the goals or criteria for judging performance.

The state of knowledge of the relationship between action and outcome, which is represented by the vertical axis in Figure 4, focuses on the understanding of how to solve

and execute a solution to the problem. Degree of consensus about the goals or criteria for judging performance, which is represented by the horizontal axis in Figure 4, focuses on the problem formulation.

The "four corners" of Figure 4 represent the problem solving systems, with different characteristics and for convenience different names.

a. Management Science

A problem in the management science realm is characterized by a high state of knowledge of the actions and their outcomes and a high state of goal consensus.

Since there is a high state of goal consensus it is known what to do and since there is a high state of knowledge about what tasks need to be accomplished it is known how to do it. This allows the pre-planing of the heuristic for assessing the situation, for identifying the problem, for solving the problem and for implementing a solution.

b. Garbage Can

A problem in the garbage can realm is characterized by a low state of knowledge and low goal consensus. This type of problem is also referred to as "organized anarchy". Since there is a low state of goal consensus it is not known what needs to be done and since there is a low state of knowledge it is not known what tasks need to be accomplish. It can be thought of as a search procedure to discover both what to do and how to do it.

The garbage can organizational decision system is characterized by four attributes:

1. Problematic preferences: goals, problems, alternatives and solutions are not well defined

2. A poorly understood technology

3. Turnover of participants involved in the problem solving system

4. The existence of choice opportunities: events where problems and solutions must be linked (e.g., budgets, contract signings and new system authorizations)

c. *Carnegie*

Since the Carnegie model is characterized by a low goal consensus it is not known what to do but since there is a high state of knowledge about the tasks that need to be accomplished if it were known what to do it, would also be known how to do it (i.e., the technology exists to accomplish the goals but it is not understood which goal needs to be accomplished). The Carnegie model of organizational decision making focuses on resolving what needs to be done – the foundation of the problem.

The Carnegie model involves a problem solving system that uses three steps:

1. The formation of coalitions around a concept of what to do. It is necessary to build a coalition among the decision makers in order to achieve goal consensus.

2. Coalitions inter and intra-bargain about the proper goal thus putting the focus on what the problem is vice what the solution is.

3. If the above process results in goal consensus then there is a switch toward the Management Science decision process. If not the system continues to cycle until there is a goal consensus.

d. *Incremental*

A problem solving system in the Incremental realm is characterized by a low state of knowledge of the action-to-outcome relationship and high goal consensus.

The goal is understood but not the means to accomplish that goal. The result of this predicament is an incremental search for the solution. The search consists of a series of smaller decisions which cumulatively produce a major decision.

There are three phases to the search; the identification phase (identifying exactly what the problem is that needs to be resolved), the diagnosis phase (formulation of the problem), and the development phase (solution shaping occurs). The development phase has two modes of operation. One mode is a search for solutions within the current repertoire of known solutions (e.g., if you have a cold the doctor might recommend a known cold medicine to see if that would provide relief because it has worked on other patients in the past). The other mode involves a newly designed custom solution which happens when a search among the tried and true methods does not produce a result (e.g., a company would write its own software when it could not find any "Off the Shelf" software that satisfies its needs). The Incremental method tends to lead to a solution design that is one of trial and error involving many steps and therefore an incremental approach.

B. C2 AS ORGANIZATIONAL CONFIGURATIONS

1. Introduction

The first, and usually the easiest way, to describe an organization is by its organizational configuration; simple, functional, divisional, matrix, bureaucracy and ad hoc. An organization's configuration is the general way of how work is divided, breaking tasks into sub-tasks and coordinating activities. In the author's opinion there

are basically two types of configurations that will be commonly found in a military environment; divisional and functional.

This chapter is going to examine these two organizational configurations of interest to military organizations and how they handle tasks.

2. Divisional

A divisional configuration is characterized by organizational subunits based on a grouping of tasks focused on mission or product to be performed or produced. An example of a divisional configuration would be all of the AAW resources, regardless of what weapon platform they are on in a carrier battle group would be organized as part of the AAW division.

Divisional fit is characterized by the units being relatively autonomous and top management is not involved in operational and tactical issues but is mainly concerned with strategic issues.

3. Functional

An organization that is structured functionally is characterized by unit grouping based on an internal functional specialization. This functional representation could be something along the lines of marketing, finance and operations in a business organization or engineering, weapons and supply in a military organization. Top management is required to be involved in strategic decision making and also is involved, to a great extent, in tactical issues due to the high need for coordination in a functional organization.

An example of a functional organization contrasted to divisional organization would be if all of the weapons on a ship were in one unit (i.e., this is usually called the weapons division). If the grouping were based on task, such as air defense, then the radar operators, the missile fire control technicians and the supply personnel that handle the missile issues would all be in the same division. In the above example it obviously makes little sense to have a divisional grouping. There are times, however, when a divisional grouping would make sense such as when the opponent has denied the friendly forces the ability to communicate. If the commander has made his intentions and goals clear to his subordinate commanders then the capability to rapidly switch to a divisional organization, which is characterized by units being relatively autonomous, will allow the organization to adapt to its new environment and survive. In the author's opinion an organizational reconfiguration will also generate a different decision making strategy, for example if your functional organization is in a "garbage can" decision making system mode then a reorganization to divisional would most likely produce an incremental decision making system because the number of decision makers will be decreased and thus a goal consensus will be reached and a goal consensus with low state of technology is an incremental decision making problem.

C. ENVIRONMENTAL ADAPTATION

1. Introduction

The goal for an organization is to be able to adapt to its environment and this is achieved through the concept of fit. Fit is how well an organization can adapt itself to its environment. Since an organization that is highly effective, efficient and viable at

adaptation achieves the proper fit for its environment then fit can be used as a measure of performance.

There are four kinds of fit involved in this adaptation; Situation Fit, Design Parameter Fit, Contingency Fit and Total Fit. In short, Situation Fit is the circumstances that an organization is forced to deal with in designing the proper fit for an organization. Design Parameter Fit consists of the structural configuration and properties that an organization can adjust to achieve a good Total Fit. Total Fit is how well the organization has adapted to its environment. Contingency Fit is fit of the underlying science to the design circumstances. It explains how Situation Fit and Design Parameter Fit scientifically based and work together. It will be discussed in more detail in the next chapter.

In this chapter the author will introduce three of the four kinds of "fit"; Situation Fit, Design Parameter Fit and Total Fit, and discuss their characteristics and how they are interrelated.

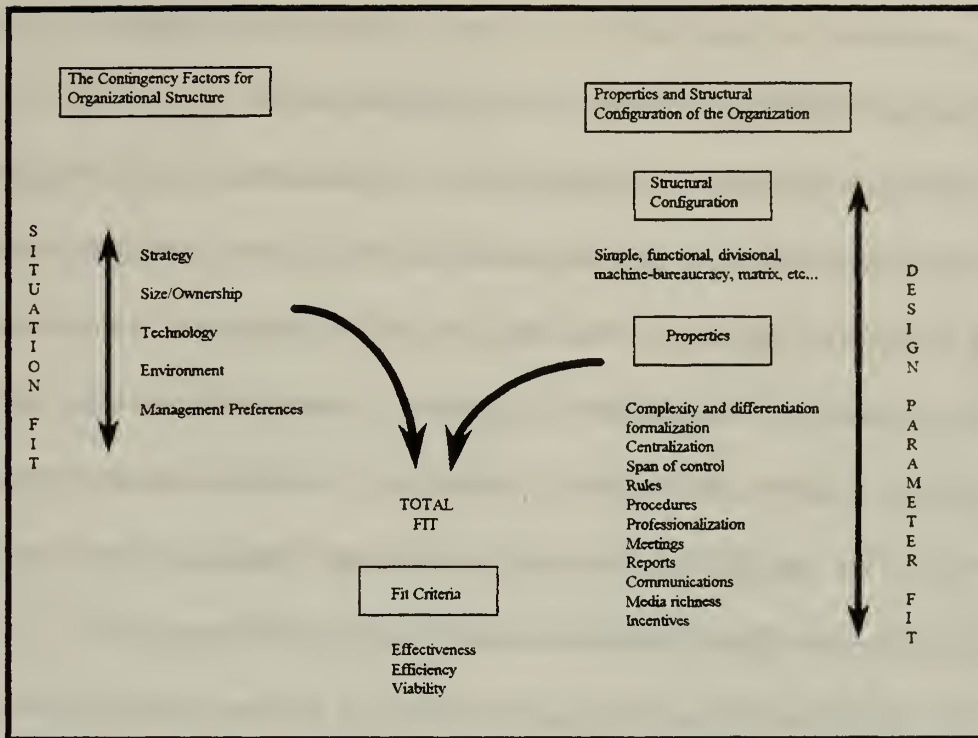


Figure 5. Organizational Design Fit. Modeled after Burton and Obel's Design fit from *Strategic Organizational Diagnosis and Design* p. 10

2. Fit Criteria

In order to understand how fit can be achieved, it is best to understand first how fit is measured. As indicated in the figure above there are three criteria that measure how well the fit is achieved. They are; effectiveness, efficiency and viability. Effectiveness is doing the right thing. Efficiency is doing it correctly. Viability is doing the right thing effectively for a specified amount of time. The performance on these criteria is determined by the situation fit and the design parameter fit.

3. Situation Fit

The situation fit is based on the contingency factors for organizational structure; strategy, size/ownership, technology, environment and management preferences. For

further explanation of the situation fits and Burton and Obels' text, *Strategic Organizational Diagnosis and Design*, is an excellent reference.

To change any of the contingency factors requires a monumental change to take place in the organization or in the environment and thus it is relatively more difficult to alter the situation fit, especially in the short term. For example one of the contingency factors for situation fit is management preferences. If the organization has a preference for centralization then it will be relatively difficult to go to a decentralized structure.

All of the situation factors should be logically consistent, "For example an equivocal environment and a routine technology do not fit." (Burton, p.11)

If a situation misfit arises it must be handled by the organization adapting to the misfit. Effective and efficient control of these situation misfits and exploitation of your opponents situation misfits may be the key to organizational success. The situation factors include: Strategy, Size/Ownership, Technology, Environment, and Management preferences. (Burton, 1995, p. 10)

The control of situational fits and misfits may actually be the key to organizational success. An organization will have to deal with any situational misfits that arise and one method of dealing with them is to purposely cause a different situational misfit to arise that the organization already understands how to deal with. Only those organizations that manage to create the proper misfits and then resolve these will be successful. (Burton, 1995, p. 11) These successful organizations succeed because they have learned how to adapt to their environment.

4. Design Parameter Fit

Design Parameter Fit are the variables that are easier to influence and thus serve as the most useful levers to achieve total fit. They are the parameters on the right side of the above diagram. Design parameter fit consists of two elements; structural configuration and properties. Structural configuration includes simple, functional, divisional, machine-bureaucracy, and matrix organizations. Properties includes complexity and differentiation, formalization, centralization, span of control, rules, procedures, professionalization, meetings, reports, communications, media richness, and incentives. These are all parameters that can be adjusted with less effort than the situation fit parameters. They are levers that are more readily available. For further explanation of the design parameter fits and situational fits Burton and Obels' text, *Strategic Organizational Diagnosis and Design*, pages 10-13, is an excellent reference.

a. Configuration and Environment

Configuration is contingent on the environment. As stated above for an organization to survive it must adapt to its environment or the organization can attempt to modify or control its environment but this is very difficult to do. Situation misfits will arise and they must be adapted to by using one of the design parameter fit variables as a lever or by realizing the situation misfit and accepting it as part of the environment.

5. Total Design Fit

The concept of total fit is that situation fit and design parameter fit are in agreement. It is possible, especially in a hostile environment with high equivocality, that total design fit is not achievable. If your situation fit is internally consistent (e.g., a large

organization with a decentralized management preference, etc....) then there is a design parameter fit that will produce a total fit. Total fit requires that the design recommendations fit together internally and more important, fit the actual situation. (Burton, 1995, p. 12)

D. CONCLUSION

This chapter serves as the basic building block to understand how an organization is effected and influenced by its environment.

For the commander of an organization to have effective command and control the commander of the organization is forced to observe his environment and take action accordingly and this is accomplished through the OODA Loop and the Information Hierarchy. The commander will be confronted with problems with varying degrees of goal consensus and states of knowledge and these problem will have to be resolved before any actions can be taken. For these actions to be effective the commander must achieve an organizational structure that will be able to adapt to the environment and achieve total fit. The environment forces the organization to attempt to achieve the proper organizational configuration. The proper organizational configuration is sometimes not achievable and thus the organization must perform a sensitivity analysis to achieve the best possible configuration for the environment it is attempting to deal with and the organization must realize that some situational misfits may exist and must be dealt with in some manner.

The proper organizational configuration leads to the proper Command and Control structure. A careful evaluation of the proper Command and Control structure

will lead to the opponents "centers of gravity" which is where the "5 Pillars of IW" can best be exploited. Desert Storm clearly demonstrated this when CENTCOM identified the Iraqi C2 as a center of gravity. Without it Saddam Hussein would have to comply with Coalition demands. (SECDEF, 1992, p. 72)

IV. MODELING COMMAND AND CONTROL FOR INFORMATION WARFARE

A. INTRODUCTION

Software designed to study organizational configuration and decision making processes is an area that has recently experienced tremendous growth due largely to the increased performance of the desktop computer. When choosing a software program it is important to understand how that software works in the broad sense (i.e., what input will trigger which events, or how they model actors and tasks to be accomplished). This chapter will introduce the various models and how they handle configuration and decision making processes. The chapter will also explore the desired characteristics of configuration (design) and decision process.

The software chosen for exploring organizational configuration was *Organizational Consultant* because of its well documented rule base, its user-friendly input interface (as user-friendly as a text-based front-end can be) and it's relatively detailed explanations of the output. *Organizational Consultant* is included with Burton and Obel's text, Strategic Organizational Diagnosis and Design . The software chosen for exploring organizational decision making processes was *Virtual Design Team* (VDT) because of its graphical user interface (GUI), which allowed easy manipulation of the actors and tasks, and because of the sensitivity analysis that it could easily perform which facilitated the evaluation of the impact of The Five Pillars of IW.

B. ORGANIZATIONAL DESIGN

For IW purposes it is of interest how an organization needs to configure itself in order to adapt to its environment and also the decision making process that an organization will use once it has adapted to its environment. It has already been discussed how an organization configures itself to adapt to its environment and how an organization makes decisions, this section introduces why organizational design and decision making processes are of interest for modeling and what features a model of these concepts should include.

1. Configuration

Environmental adaptation is absolutely necessary for an organization to survive thus the issue of organizational design is one of the dominant issues within the area of organizational science. In large part this is because organizations can alter their design and thereby adjust or adapt to the task environment (Carley, 1995, p. 42). In order to hasten this adaptation, and thus gain an advantage over your opponent who is not adapting as rapidly, the use of computer modeling can be very beneficial. A computer model allows the decision makers to evaluate the marginal return of various organizational configurations without actually spending the resources to reconfigure the organization. Not only will the decision makers be able to evaluate their own organization and improve it but they will also be able to evaluate the opponents organization and expose the opponents weaknesses that would be susceptible to IW attack.

There are numerous organizational designs that can be created and implemented

and obviously there is no way that an organization would have the time or the resources available to attempt all of the organizational configurations and determine which configuration was best for their organization. As Kathleen Carley has conclusively demonstrated there is no one best organizational design; rather, the effectiveness of an organizational design is highly contingent on various factors such as the task, the environment, and the training organizational members receive (Carley, 1995, p. 43). Task, environment and training are factors that are very important to be included in a model and to make a model truly useful theses factors must be easily adjustable. The ease of manipulation allows for the rapid performance of sensitivity analysis.

2. Decision Processes

How best to model decision making processes is an interesting proposition. An immediate issue is what level of detail is required to be effective; not enough detail and the model is not really producing any concrete results, too much detail and the model will be too slow and produce too much data to be useful to the decision makers in a highly dynamic environment. In order for information processing models of organizations to generate reasonable, concrete and policy relevant implications, the models need to include at an appropriate level of detail for the model's purpose: a model of the agent(s), a model of the task and a model of the internal structure of the organization (Carley, 1995, p.44). If a model incorporates this level of detail, it is enough to provide insight into where information is flowing and what nodes are important and more importantly what nodes are most susceptible to IW attack.

Also many organizational features can be represented as matrices of relations.

These relations may be among people or agents, between resource/tasks and people/agents, between agents and skills (Carley, 1995, p.44). If the model is based upon a matrix (or several matrices) that allows access to the matrix this will enable two very important things; firstly it will explain the underlying rule base that the model runs on and secondly, perhaps most importantly, if the underlying rule base is not appropriate for the given organization and its environment the matrix can easily be manipulated. A model based on a matrix is indeed a very flexible and powerful tool.

C. SOFTWARE USED FOR MODELING

This section will discuss the software, *Organizational Consultant* and *Virtual Design Team* software and why it was chosen for the modeling conducted in this thesis.

A software program was required that integrated the situation fit parameters with the design parameters using the science of the contingency fit to produce a total fit. This led to the selection of *Organizational Consultant. Organizational Consultant* is used to simulate organizational configuration/design because it is state of the art software and it provided the ability to easily adjust the characteristics of design parameter fit and thus adapt to the current task. Task, environment and training are factors, as stated earlier, that are very important to be included in a model which, *Organizational Consultant* does. *Organizational Consultant* also produces an output identifying any misfits and suggesting, if any, corrections to the configuration to eliminate the misfit. The accommodating interface of *Organizational Consultant* also facilitates the performance of sensitivity analysis.

To model the decision making process of an organization, software was required that had a user-friendly graphical interface and that produced quantifiable results. A model that represented some level of detail and was based upon a matrix or matrices was also highly desirable. The above reasons led to the selection of *Virtual Design Team* (VDT) to simulate organizational decision making processes because it is state of the art software, it includes a model of the agent, a model of the task and a model of the internal structure of the organization and it uses an underlying matrix (that is also easily adjusted for sensitivity analysis) to model the interaction between agents and tasks. VDT displays its results in both the graphical form, represented by actor in-tray depth (the amount of tasks to be accomplished by the actor at a specific time) and Gantt chart, and numerical form in the output file. The accommodating interface of VDT allowed for sensitivity analysis without requiring the user to perform a lot of changes to the simulation.

1. Organizational Consultant

a. Introduction

This section will discuss the *Organizational Consultant* software and in general explain how it turns input into a useable output form.

Contingency Fit is the underlying organizing concept that is used to produce the rule base that drives the *Organizational Consultant* Software. The Contingency Fit criterion is based on contingency theory literature and it is utilized in a series of "if-then" statements to reconcile Situation Fit and Design Parameter Fit. In

essence the Contingency Fit is the "organizational science" that underlies the entire notion of fit.

The solution to the problem of organizational design is difficult but its solution is very valuable. For example, an organizational structure can be defined as centralized or not, formalized or not with none, few or many departments. Even in this simple example there are 2x2x3=12 possible designs from which to choose. This number of choices grows nonlinearly as the number of organizational dimensions grows. (Burton, 1995, p. 321) Therefore it is impractical, if not impossible, to attempt to determine the proper organizational configuration without the aid of the software. If the problem is a temporal one, such as determining your opponents organizational configuration and weaknesses rapidly enough to take advantage of them in a conflict, the problem definitely becomes even more difficult.

The *Organizational Consultant* software was created in an attempt to balance the trend of current organizational theory textbooks of either being too specific or too general in detail to be of much assistance in designing the proper organizational configuration. The goal of *Organizational Consultant* is to design an appropriate organization that will be able to adapt and achieve a fit with its environment and allow this design to take place in timely enough manner that it is useable.

b. Fit Criteria

Fit is an organizing concept for the creation and development of the knowledge base (Burton, 1995, p.9). The knowledge base developed by Burton and Obel is comprised of existing contingency theory and consists of approximately 350 if-then

propositions used by the software in designing the proper organization.

"If-then" statements are a manifestation of the knowledge base to produce appropriate organizational design recommendations. The utilization of the "if-then" statements can also identify fit mismatches. For example proposition 4.5 states, "If the organization is large and not private, then centralization should be low" or proposition 5.9 states, "If the environment is hostile then formalization should be low, organizational complexity should be low, and centralization should be very high". As a result the knowledge base forces the user to make compromises and design trade-offs especially if the environment has a high degree of equivocality. An example of an environment with a high degree of equivocality would be one where a JTF has been invited by a host country that is normally neutral or unfriendly to the U.S. to provide humanitarian assistance due to a major natural catastrophe. Though the host country has invited U.S. forces into the country it is not known to the U.S. forces if the host population will be friendly to the U.S. forces or might they become hostile.

c. Contingency Fit

Contingency fit is the underlying organizing concept that joins together the situation fit and design parameter fit. Contingency fit, as used by the *Organizational Consultant* software, represents the empirical study of contingency theory. The contingency fit criterion has largely been achieved through careful attention to the contingency theory literature and translation of that knowledge into appropriate if-then statements.

Each If-then contingency proposition must be consistent with the

contingency theory and represent the knowledge base as well as be consistent with an information-processing argument. (Burton, 1995, p.10)

Contingency fit is important to the performance of the organization for it exposes the mismatches which the organization will have to manage. Interestingly enough each contingency fit may lead to more than one design recommendation and thus the best design for the organization at the time must be decided on and the mismatches that the design will produce must be anticipated. The anticipation of the mismatches will allow an organization to pre-plan how they will deal with the mismatches and the software can aid with this pre-planing. For example a JTF is sent to Southwest Asia to deal with an Iraqi troop build up. It is a small force and has a highly centralized management preference. The organization, using *Organizational Consultant*, would be able to model how the organization configuration is going to have to change in order to adapt to the environment. *Organizational Consultant* would identify that the centralized management preference is going to generate a mismatch. The organization could then simulate various organizational configurations to determine how best to deal with this mismatch.

d. Structural Configuration and Properties as Levers of Change

As stated earlier it is easier to manipulate the design parameter fit variables as opposed to the situation fit variables. Thus, the design fit variables serve as an excellent lever of change. A predicament arises in *Organizational Consultant* in that for the questions asked by the software there are a finite set of answers that may not correctly match the desired input. The software overcomes this limitation by the use of

confidence factors which allows the input to be as close as possible to one of the software responses. Then a confidence factor is assigned to the input to correlate the input and the software response. For each design parameter, the set of if-then propositions that lead to a design recommendation must fit and be in balance (Burton, 1995, p. 11). Conflicting design recommendations can be generated and these must be accommodated based on which of the recommendations is stronger. For example a large organization may suggest a decentralized management style but management might favor a "hands-on" management style. Certainty factor (cf) helps decide which of the two recommendations would be more pertinent. For the purposes of this thesis a certainty factor between 21 and 30 indicates low certainty about the if-then statement , 30 to 60 indicates a medium level of certainty about the if-then statement, and greater than 60 indicates a high level of certainty about the if-then statement.

More information can be found on the Structural Configuration and Properties in Burton and Obel's text, Strategic Organizational Diagnosis and Design.

2. Virtual Design Team

Where a commander knows how to configure an organization to adapt to its environment and/or how to evaluate an opponent's configuration, it is equally important to be able to understand an organization's information processing capability. The ability for an organization to function properly depends on the coordination and control of its activities. An organization processes information to coordinate and control these activities. Organizations, including project organizations, need information flows to function, and strive to create efficient information flows to be effective (Jin, 1996, p. 4).

One of the main goals of an organization is the processing of information in order to function properly in its environment. The opponent's organization is also attempting to process information in order to function properly, thus the goal is to execute the OODA Loop faster and more efficiently and effectively than the opponent. The essence of *VDT* is that it captures this information flow and demonstrates (by Gantt chart or In-tray chart) where the information is not flowing effectively or effectively. This illustration by *VDT* clearly demonstrates by its GUI where to exploit your opponent's vulnerabilities or just as importantly, where to defend your own vulnerabilities. This capability to determine visually, as opposed to having to sort through reams of text data, enables the faster execution of the OODA Loop.

This information-processing view of organizations provides a foundation for the *VDT* model. In *VDT*, it is possible to model design teams as information-processing structures that are composed of tasks generating information to be processed, actors processing and communicating information, communication tools linking actors for communication, and an organization structure that constrains actor's information-processing and communication behavior (Jin, 1996, p.5). This capability allows the level of detail that Carley stated was necessary to model the decision making processes of the organization.

There are several methods to model the decision making process and one of them is known as the Critical Path Method (CPM). While the CPM models sequential interdependencies through explicit representation of precedence relationships between activities, it does not take into account reciprocal information requirements between

concurrent activities, nor the impacts of actor interactions. The ability to model reciprocal information requirements in the IW arena is very important because of the numerous nested loops that occur simultaneously while the commander is attempting to cycle through the OODA Loop faster than his opponent. At the same time, contingency theory can provide only limited answers to these questions because of its aggregated view of organizations and its relatively general definitions of contingency factors (Jin, 1996, p.2). Contingency theory also tends to represent a static environment while the capability to represent a dynamic environment is very desirable if the goal is to model information flow in a decision making process.

VDT explicitly represents an organization's tasks, its actors, and organizational structure. For a given task and organizational setting, *VDT* can generate emergent organizational performance through simulation of micro-level actions of, and interactions among, the actors in the organization and the information flow between them.

The work that is done in any organization on a product can be divided into two parts: the primary production work that directly adds value to the final product and coordination work that supports the primary production work.

The primary production work is relatively straightforward to model and understand how it affects the organization. Any link/node that is associated with the primary production work can be easily exploited by the "destruct pillar". The coordination work is of particular modeling interest because it is these links/nodes that represent the coordination work that are susceptible to exploitation by the other four pillars of IW.

VDT's unique ability to model these two forms of work makes it an attractive program to attempt to understand the effects of IW on an organization. As for the current state of VDT, it is being commercialized by its developers and Stanford University through a start-up company called Vité (776 Tolman Drive, Stanford, CA 94305, Phone/fax: 415/857-0632, www.vite.com).

There are two basic requirements for a *VDT* task model. First, the model must capture enough details of both work contents and activity dependencies so that both production work and coordination work can be generated. The challenge here is how to make the model simple, but effective, across many specific types of design projects, remembering that a simple model will be faster to create (time is of the essence in an IW environment) and easier to understand. The second requirement is to be able to map the model attributes to accessible, real project data, so that the model is comparable with real project information and that the insights generated from the model are realistic. The ability to model real project data will lend relevance to the marginal analysis (Jin, 1996, p.8).

In the author's opinion, task interdependencies are one of the main drivers of uncertainty and the ability to model these task interdependencies is a crucial step in understanding organizational decision making processes. *VDT* allows the modeling of pooled, sequential and reciprocal dependencies and also the ability to coordinate the amount and content of production work.

Another aspect of importance is the way that decision makers will divide their attention to information that is being presented. *VDT* allows the modeling of actor

attention allocation which is how an actor chooses which task to work on when it faces alternatives. This variable adds realism to the model because it allows for events to take up all of the actors attention or move to the "front of the actors queue" that a CPM model would not allow.

As detailed above *VDT* delivers several attractive modeling attributes that are crucial to modeling a decision making process. For further information on the characteristics of *VDT* an excellent source is Yan Jin and Raymond Levitt's *The Virtual Design Team: A Computational Model of Project Organizations*, 1996.

V. ORGANIZATIONAL CONFIGURATION IN INFORMATION WARFARE

A. INTRODUCTION

The goal of any organization is to adapt to its environment. In order for this adaptation to occur, the situation factors must be internally consistent (e.g., a large organization must have a decentralized management preference, a centralized management preference would produce a situation misfit). If the situation factors are internally consistent then there is a set of design parameters that will produce a total fit (whether the organization uses this set of design parameter that produce a total fit is a different question). When total fit is achieved the organization has adapted to its environment.

It can be very difficult for military organizations to adapt to their environment because of the environment's hostility (i.e., constant dynamic state with severe consequences for wrong organizational configurations) and its high equivocality. But the ability to model an organization in these circumstances is of tremendous benefit for two reasons. Firstly, a commander can model his/her own organization and discover what misfits there are and also model how best to deal with these misfits. This modeling ability costs the commander few resources (i.e., time, money, equipment or personnel) and will allow the observation of several variations of an organizational configuration, discovering all of their strengths and weaknesses, before choosing the proper organizational configuration. Secondly, a commander will be able to model the

opponent's organization and discover the opponents misfits. Once the opponent's misfits are discovered the commander can then model what will happen to the opponent's organization if these misfits are exploited. An example would be a large army that has a very centralized chain of command (remember a large organization has to have a decentralized management preference to have its situation fit internally) thus producing a situational misfit. This situational misfit would serve as a flag to the commander that one of The 5 Pillars of IW could be used to the commander's advantage (the one that immediately comes to mind is the destruct pillar because as stated earlier it would deny the enemy command and control of their forces).

In this chapter a scenario is developed and then the *Organizational Consultant* software is used to examine the organization and refine it so it can be adapted to its environment. That is, determine what misfits, if any, are in existence, and how they should be assimilated or eliminated. The scenario is a non-combatant operation, so there is no opponent organization to model.

B. THE SCENARIO

This scenario is based on conducting an operation similar in nature to Operation Sea Angel, the 1991 relief effort to assist the people of Bangladesh after Cyclone 02B swept through the country killing over 140,000 people.

The location is the tropical Pacific. A small island nation is struck by a major earthquake destroying the capital city and most of the nation's physical infrastructure. Torrential seasonal rainfall has complicated the situation. An embarked Marine Expeditionary Force (MEF) is in the region in route to scheduled exercises. The island

nation's government requests assistance from the United Nations and the American Ambassador to the United Nations convinces the President that providing assistance is a good idea. The Commander of the MEF is designated the CJTF for the relief effort and ordered to report to the American Ambassador on the island.

The organization is assumed to include the traditional JTF elements and two additional entities to enable successful mission completion. The priorities for the mission will be set by an executive council consisting of the host nation's representatives, the American Ambassador and the CJTF. Immediately beneath this body will be the Coordinating Council consisting of selected members of the CJTF's staff, embassy personnel, host nation representatives and representatives of all Non-government organizations (NGOs), private volunteer organizations (PVOs) and other participants. The goal is to eliminate conflicts between competing interests at the higher levels to enable routine accomplishment of logistical, medical and communications tasking.

The entire area of operations is assumed to be roughly circular with a radius of less than 500 miles. The nation is mostly mountainous tropical jungles with few major cities. There is assumed to be no conflict or strife of any type and thus no resistance will be expected to the presence of United States forces.

C. INPUT

Organizational Consultant uses 11 characteristics of an organization to analyze it: Current Configuration, Complexity, Formalization, Centralization, Size, Age/Ownership, Diversity, Technology, Environment, Management Profiles and Strategy Factors. Current

Configuration specifies the way an organization divides work, breaks tasks into subtasks and the coordination of these activities. An organizational configuration can be described as simple, functional, divisional, matrix, machine bureaucracy, professional bureaucracy or ad hoc (Burton, 1995, p. 48). In the scenario the current configuration is described as functional.

Complexity is a measure of the horizontal (the specialization within an organization), vertical (the depth of the organizational hierarchy) and spatial (the geographical dispersion of the organizations activities) differentiation. As the degree of organizational complexity increases the need for coordination of issues and the requirements for organizational information processing increase (Burton, 1995, p. 70). In the scenario the complexity is characterized by six to eight vertical levels, three to five geographical locations and a moderate number of different jobs.

Formalization is how an organization achieves standardized behavior, coordination and control. Formalization is correlated to the amount of written rules and procedures. The greater the amount of written rules and procedures the higher the formalization (Burton, 1995, p. 74). In the scenario the formalization is characterized by job descriptions being available for all employees and supervision of those job descriptions is moderately close.

Centralization is the degree to which formal decision making authority rests with an individual, unit or level. A measure of centralization is how much direct involvement top mangers have in gathering and interpreting the information they use in the organizational decision making process. The more involved top management is the

greater the centralization (Burton, 1995, p. 75). In the scenario top management is involved in the information gathering and interpretation of that information but top management only directly controls less that 20% of the decisions executed.

Size is a measure of how many people work for the organization and *Organizational Consultant* breaks it down into small (less than 100), medium with less impact (101-500), medium (501-1000), large with less impact (1001-2000) and large (greater than 2000) (Burton, 1995, p. 125). Size issues are most closely associated with centralization issues for as size increases centralization must decrease to avoid situation misfits. In the scenario the size is 7500 personnel.

Organizational Consultant breaks Age/Ownership into young, mature and old and ownership as private, incorporated, public, and subsidiary which only have a minor influence on the appropriate design (Burton, 1995, p. 359). In the scenario the age is young and the ownership status is public.

Diversity is a measurement of the number of different products that the organization produces, the number of markets that the organization competes in and the number of markets in which the organization operates overseas. In the scenario the diversity is characterized by few different products and few different markets.

Technology is the information, equipment, techniques and processes required to transform inputs into outputs. Technology is used to describe an organization as manufacturing, service, retail or wholesale and its production as mass production, process production or unit production. Technology is also divided into routine (if tasks are well defined and understood and rules are written down and followed), non-routine,

and whether it is highly or lowly divisible (divisibility is the degree to which tasks can be divided into smaller and relatively more independent tasks). (Burton, 1995, p.197-198) In the scenario the technology is described as a service organization that is customer oriented with a routine technology that is somewhat divisible.

Organizational Consultant describes the organization as either simple or complex, by the amount of uncertainty, by the amount of equivocality and the degree of hostility. To understand and fit the environment requires an information-processing capability commensurate with the uncertainty in the environment (Burton, 1995, p. 144). In the scenario the organization is described as a complex organizational environment with a low level of uncertainty, equivocality and hostility.

Strategy is defined in *Organizational Consultant* by the terms Defender, Prospector, Analyzer and Reactor. These terms are a measurement of the capital requirement, product innovation, process innovation, price level and organizational concern for quality (Burton, 1995, pp. 219-220). In the scenario the strategy is characterized as a defender strategy.

This is just a brief synopsis of how *Organization Consultant* characterizes an organization. (For further explanation the author suggest the Burton text, *Strategic Organizational Diagnosis and Design*, pages 87-254.)

The input to the Organizational Consultant Questions for this scenario and the reasoning behind them can be found in Appendix A. There are several areas of interest because they highlight the difficulty of adapting software written for civilian organizations to military organizations. For example the question "How many different

job titles are there" (Q:1 in the complexity section). In a military organization there are few job titles in the vertical dimension but horizontally there are a large number, thus it is up to the software user to decide on the appropriate answer. Another example is the question "Written job descriptions available for" (Q:1 in the formalization section). Every member has a written job description but due to the hostility and the equivocality of the environment the written job description may not match the job actually being performed. Another example is the question "How much discretion does the typical middle manager have over personnel rewards (i.e., salary increases and promotions)". In a military organization the middle manager can not give a salary increase or a promotion but the middle manager can give special liberty, recommend the individual for an award (non-monetary) or give them an excellent performance appraisal. The question is, "Are these kinds of rewards the same as the rewards meant by the question"? It is up to the individual *Organizational Consultant* to resolve issues like this and it is possible each user will interpret the question differently.

For the research leading up to this thesis, 10 military officers were broken into three groups and asked to run a military organization through *Organizational Consultant*. On numerous questions three different inputs were used because all three groups had interpreted the question differently. All three were modeling JTFs, yet answers still varied. For example, one question asks "How old is the organization" (Q:1 in the Age/Ownership section) and answers varied from young to mature. "Young" was used by one group because the JTF was formed to handle a specific mission and thus it was only a few weeks old. Where as "mature" was used by another group because JTFs

have been around for several decades now and the technology and issues of a JTF are well understood. Both answers are seemingly correct but both lead to different organizational configurations. Once again it is up to the individual *Organizational Consultant* user inputting the data to reconcile the differences and decide on the best answer.

An interesting side note is that if all of the underlying rule base were known to the user, as well as how the selection of an answer effects the outcome, it would be easier to understand the significance of the input. It could also shed some insight on what exactly the writers of the software intended by their question, hence an expert would be better at organizational configuration than a novice would be.

As mentioned in the preceding chapter *Organizational Consultant* allows the user to associate a confidence factor (cf) with the input. In studying military organizational configuration with *Organizational Consultant* this capability can be an asset or a liability. The reason the author believes this is because *Organizational Consultant* was written for the civilian commercial sector and as demonstrated above several of the input questions have an ambiguous meaning when applied to military context. The alteration of a cf to a question that is already ambiguous will only increase the amount of uncertainty with the question and the answer applied. In the author's opinion this is currently one of the limiting factors of using any commercial sector data based organizational design software.

D. RESULTS

The input and the results from *Organizational Consultant* can be found in Appendix A. Of particular note is the results produced by *Organizational Consultant* is that while *Organizational Consultant* found no organizational misfits it did find situation misfits [there are situation misfits (cf 100)]. As stated earlier a certainty factor between 21 and 30 indicates low certainty about the if-then statement , 30 to 60 indicates a medium level of certainty about the if-then statement, and greater than 60 indicates a high level of certainty about the if-then statement. Thus a cf of 100 is a very strong statement.

The Organization has both a routine technology (e.g., tasks are well defined and understood and control is obtained through the application of rules) and a high requirement for product innovation (the capability to develop new products in order to adapt to the environment). This may cause problems due to the fact that a routine technology does not support a requirement for high product innovation because the capability to be innovative requires that there be few written rules and procedures to follow. When many factors in the environment affect the organization, it may make it is difficult for a defender. Defender is a strategy term. It means the organization protects what it does and seeks to protect its established market position. For further explanation see Burton and Obel, pages 226 through 243 Another issue to be addressed when adapting civilian data-based organizational design software to a military environment, is what is market position? Therefore, the defender strategy is not appropriate for the organization. *Organizational Consultant* can not determine what the proper strategy is

thus it is a misfit that will have to be dealt with by the organization. Though *Organizational Consultant* did not identify the proper strategy, it has identified the mis-match that is being generated by the conflict between the requirement for innovation and the routine technology. This information allows the commander to decide which of these two opposing values is more important to the organization and then attempt to configure and reconcile the organization with the move important value. For example, the JTF in the above scenario is dealing with a humanitarian operation that involves a host nation and several third party members. This is certainly an area where there are few rules of procedures written down for the JTF and the environment is a highly complex one. These factors, in the author's opinion, would lead to the conclusion that the ability to innovate is highly prized and thus the commander should reconcile the misfit by eliminating the routine technology represented by the rules and procedures that a JTF would normally have to adhere to.

A limitation of the *Organizational Consultant* is that it considers only a static environment. If the organization being modeled is operating in a very dynamic environment, as this one is, in that it can go from a neutral environment to a hostile environment rapidly, then the organization has to be able to rapidly adapt to the environmental change. Flexibility is extremely important. *Organizational Consultant* has to be applied in a "brute force" sample of the environment over time to be helpful, that is *Organizational Consultant* should be used with every cycle of the OODA Loop to compensate for its inability to view a dynamic environment.

So far *Organizational Consultant* has been used as a tool to model the JTF organization but it can also be used to model the opponents organization. By modeling the opponent's organization it will expose any misfits that are present in their organization. Once those misfits are identified, *Organizational Consultant* then can be used to explore how much of a misfit is present by performing sensitivity analysis. For example, greater hostility requires greater centralization of the organization. If the opponents organization is currently described as "Q: How much direct involvement does top management have in gathering the information they will use in making decisions? A: Some" the program describes the organizational misfits produced by driving that answer to little or none. This capability to perform sensitivity analysis can not be overvalued. It allows the commander to expend few resources to examine countless organizational configurations before choosing the correct organizational configuration for the environment. It allows the commander to identify problems, if any, that could possibly arise, and it allows the commander to model how best to deal with those problems if they do arise. The relatively rapid speed of the program allows the commander to perform all of this analysis in a dynamic environment. In short the ability to perform this sensitivity analysis gives the commander an invaluable tool.

E. CONCLUSION

For an organization to survive and thrive in an environment it must adapt to it. This adaptation problem is made even more challenging when the environment is dynamic and hostile in nature. The more dynamic and hostile the environment, the less room for error to choose the correct organizational configuration to achieve this

adaptation. The ability to model not only the present environment but also the potential future environments allows the commander the luxury of exploring various organizational configurations without the burden of spending his scarce resources. This is why it is essential that a commander be provided the tools to model his environment.

VI. ORGANIZATIONAL DECISION PROCESS IN INFORMATION WARFARE

A. INTRODUCTION

The organizational configuration developed in the last chapter using *Organizational Consultant* is the configuration basis for studying the decision processes and how they are modeled by *VDT*. The *VDT* software is used to determine each pillars marginal return (i.e., the cost to conduct the attack versus the cost of the damage the attack will produce) if an attack is performed on it. While there is no opponent in the scenario, consider the possibility of someone deciding to perform an IW attack against the commander's organization. To ameliorate this possibility the commander chooses to perform a vulnerability analysis of the organization. The vulnerability analysis is conducted by simulating an IW attack against the commander's own organization and the impact of the IW attack on the decision process is measured.

B. THE SCENARIO

The scenario used was the same scenario as that used for Information Warfare Impact on a Joint Task Force Configuration mentioned above with a slight modification. In the scenario the environmental hostility and equivocality was described as low. The commander has received word that a leftist rebel group has decided to take advantage of the natural disaster and convince the illiterate population that the disaster is the fault of the Americans and the time to overthrow the island's government has arrived. The commander realizes that the rebels will militarily be little challenge but if the can exploit

the IW pillars they could be a significant threat. Thus, the commander orders an IW attack on his own organization to be modeled to determine the organizations vulnerabilities.

C. THE ANALYTICAL APPROACH

1. Scenario Aspects for Virtual Design Team

The input for this scenario is detailed in Appendix B. It is the .opd (which is a text file) used by the VDT software. All of the parameters can be read from the .opd file or the file can be opened in *VDT* which will display a graphic representation that can only be understood on a color monitor due to different colors representing different actions.

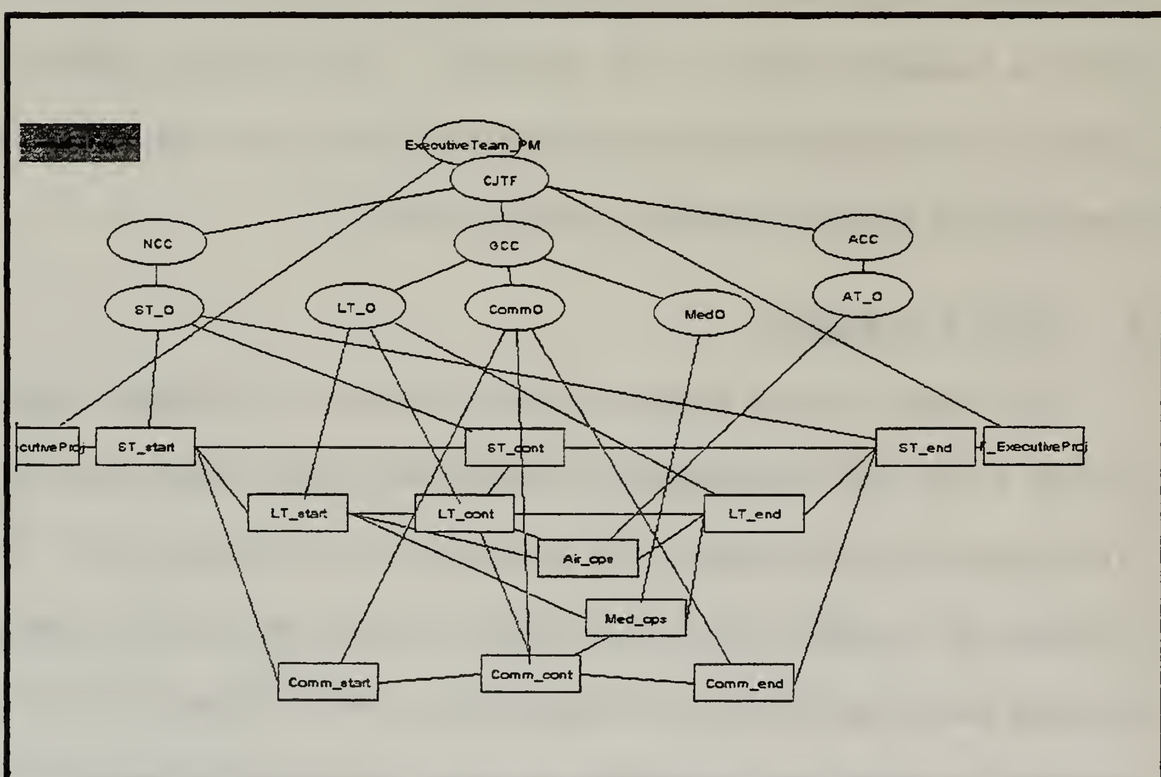


Figure 6. Humanitarian organizational configuration used for VDT simulation saved as a black and white.

Above is a black and white reproduction of the .opd file that loses a lot of its functionality when it is not displayed in color. The colors allow a visual representation of interdependencies which quickly leads the viewer to the notion that "if *A* fails then it will effect *B*". The graphical representation of the .opd file is inserted in this thesis mainly to illustrate the organizational configuration used in the scenario and to give an example of what Appendix B looks like when opened in *VDT*.

Each .opd file requires that there be a beginning and an end to the project (S_ExecutiveProj and F_ExecutiveProj) and a Project Manager (ExecutiveTeam_PM). Actors in VDT are represented by an oval. The scenario has a commander (CJTF) who is responsible for the mission and he directly supervises the Naval Component Commander (NCC), the Ground Component Commander (GCC), and the Air Component Commander (ACC). The NCC directly supervises the Sea Transport Officer (ST_O). The GCC directly supervises the Land Transport Officer (LT_O), the Communications Officer (CommO) and the Medical Operations Officer (MedO). The ACC directly supervises the Air Transport Officer (AT_O).

Activities in VDT are represented by a box. The ST_O is responsible for the start (ST_start), continuation (ST_cont) and the finish (ST_end) of sea transport activities (i.e., moving the troops and supplies ashore via ship). If there is an exception (remember from above that when an exception is generated it can either be ignored, reworked or repaired) between any of these three activities they will be handled by the ST_O (and how they are handled by the ST_O is controlled by the behavioral matrix and hence is an adjustable variable for further sensitivity analysis).

The LT_O is responsible for the start (LT_start), continuation (LT_cont) and the finish (LT_end) of land transport activities (i.e., moving the troops and supplies around once they have reached the shore). The LT_O will handle any exceptions that arise between the LT activities.

The CommO is responsible for the start (Comm_start), continuation (Comm_cont) and the finish (Comm_end) of communications activities. The CommO will handle any exceptions that arise between the Comm activities.

The MedO is responsible for the medical operations (Med_ops) and the AT_O is responsible for the air operations (Air_ops).

Notice in Figure 6. that the ST, LT, Comm, Med_ops and Air_ops are occurring in parallel (i.e., they are occurring simultaneously). If there is an exception between different activities that have different actors (e.g., an exception arises between ST_cont and LT_cont) the exception will have to be resolved in the hierarchy where the two actors meet (in the above example that would be the task of the CJTF actor to resolve the exception).

Figure 6, if it were in color, would show that there is a "reciprocal with" relationship between ST_cont and LT_cont, LT_cont and Air_ops, LT_cont and Med_ops which indicates that if one part of any of these relationships is overburdened it can shift its workload to its "reciprocal with" relationship. For example, if the ST_cont becomes overburdened (e.g., the number of exceptions is so high that it can not do its job) then it could transfer its workload to LT_cont. What might cause a situation like this to arise in the scenario is if some group were to mine the harbor then the ST_cont

would have to divert assets to finding and eliminating these mines instead of moving troops and supplies.

Figure 6, if it were in color, would show a "failure dependent" relationship between ST_cont and LT_cont, LT_cont and Air_ops, and LT_cont and Comm_cont. A failure dependent relationship means that if the activity completely fails then the activity that it has the failure dependent relationship with will also completely fail. So, if an activity that has both relationships, like ST_cont and LT_cont, it is all right as long as one of the activities doesn't completely fail. Elaborating on the earlier example as long as the ST_cont was still functioning, no matter how slowly, the task will be accomplished. If the ST_cont should fail (e.g., the ships all hit mines and were destroyed) then that would cause the LT_cont to fail. And because of the other failure dependent relationships that would cause Air_ops and Comm_cont to fail thus the entire operation would fail.

The capability to display the information flow in a graphic manner is a highly valued characteristic because it saves countless man-hours compared to attempting to decipher the information flow from the .opd file. Another advantage that *VDT* has is that the underlying matrix that drives *VDT* is the behavioral matrix which is also a text file, and since it is a text file it is easy to understand and also easy to manipulate. The capability to observe the behavioral matrix serves two useful purposes. Firstly, it allows the user to view the connections between the behavioral matrix and the .opd file being created for the simulation thus allowing the software user to gain some insight as to which variables effect which other variables. Secondly, and more importantly especially

when adapting commercial software for military use, is the capability to easily manipulate the behavioral matrix to reflect more closely the military environment.

VDT has the ability to define actor skill levels, task requirements and complexity variables as low, medium or high and this facilitates the capability to perform sensitivity analysis. The initial run of the model, the output file is shown in Appendix C, was used for the base configuration data. Then the effects of IW operations were simulated by raising the uncertainty of target activities from low to high and the complexity variables from medium to high and low. The results from these IW attacks are shown in Figure 7.

2. Measures of Performance for Virtual Design Team Simulations

The ability to measure the performance of various parts of the model is extremely important to the commander so that the identification of resources that are not being used to their potential can be better utilized. Unfortunately, the association of concrete numbers to a *VDT* simulation is such a large task that it would slow down the process to the extent that the commander would have difficulty cycling through the OODA Loop in a timely fashion. The strength of VDT is that if the model is applied correctly on the first run showing the relative duration of each activity (i.e., if one activity takes twice as long as another one then those duration variable are altered accordingly) then when an IW attack is conducted it will demonstrate the measurements to that same relative scale. For example, if in the scenario it was modeled that ST_cont took twice as long as LT_cont then any IW attack on ST_cont would show the same relative degree with respect to LT_cont as if the numerous hours had been invested to model the exact costs. Thus, the same result is achieved with hours less time invested and the commander is still cycling

through the OODA Loop in a timely manner.

3. Methods of Initiating Attacks

VDT's capability to model information flow and demonstrate where bottlenecks occurred proves extremely useful to model IW attacks because it can clearly demonstrate when a decision maker becomes so over burdened that information no longer flows properly. *VDT* can be used to determine when the best time for the attack is (attack timing), the best target to choose and what combinations of these two variables will produce the most optimum results. The costs associated with the attack, both to the commander and to the opponent, are not necessarily monetary costs, they include time and resources available to both sides in a conflict. *VDT* is capable of not only modeling time used for a project but also resources, to include financial, used for a project.

a. *Attack Timing*

A user equipped with *VDT* can determine when an attack will be most effective, cause the greatest disruption, or whether it is worth the attempt to disrupt the effort at all. Realizing that some targets are more valuable targets then others (i.e., their disruption produces far greater costs to the opponent than the cost of the attack does to the friendly forces) the capability to model all of the potential targets for their marginal return of attack while expending few resources and completing all of this modeling in a timely manner is a valuable asset that any commander would desire. For example, a model could be run to determine if it produces more disruption to interrupt the sea transport at the start (ST_start) in the middle (ST_cont) or at the end (ST_end).

b. Target Type

As stated earlier the cost of the attack versus the cost to the opponent is a vital piece of information. There is no sense in risking precious resources to attack a node/link that the opponent rarely uses. A user equipped with *VDT* can determine that if an actor is attacked what the marginal return of that attack measured in decision process terms is and thus a commander can determine if that attack is justified. For example if the opponent decided to expend their precious resources to thwart the operation they could model the destruction of the ST_start, LT_start and Comm_start and realize the costs to destroy these three targets but they would also see in the model that the elimination of the ST_cont with its failure dependencies would stop the entire operation, thus the model would tell them that the optimal target is the ST_cont.

c. Combinations

The capability to model the adjustment of one variable is worthwhile in a model but the capability to adjust not only the target type but also the attack timing suddenly opens up a new realm of possibilities to the commander and the planning staff. A user equipped with *VDT* can compare target type and timing attacks in various combinations to determine the optimum use of the available resources to the commander. This capability to model an attack in two dimensions (target type and attack timing) is a useful capability because it allows the commander to investigate more options in less time.

The scenario used produced a rather simplistic model in that one key activity could be eliminated which would stop the entire mission thus there is no real

need to model in the two dimensions. If a more complex model were being used where there wasn't one key activity that would stop the entire project then there would be a reason to model in two dimensions.

d. Attack Type

The commander has Five Pillars of IW to attack against his opponent and they capability to determine the costs to attack a pillar versus the attacks costs to the opponent is a valuable one. A user equipped with *VDT* can model if it is more effective to eliminate an activity (i.e., the destruct pillar) or just to degrade it. For example, if the opponent announced to CNN (and thus the CJTF) that they were going to specifically attempt to take hostage all of the medical personnel (thus using the PSYOP) pillar then the commander could respond by moving the medical personnel back out to the ships. This movement of the medical personnel would hinder the transport of troops and supplies thus slowing down the activities and the enemy expended no more resources than sparing one of their personnel for a CNN interview yet they accomplished the same as destroying one of the activities.

D. THE RESULTS

1. Introduction

The results for the original run of the model are contained in Appendix C. These results show the calculated duration, that is if everything operates perfectly, which was 18057 (units are not important since the IW attacks are looking at comparisons thus the measurement is relative) while the actual duration was 18591. The difference is caused by the number of exceptions and how they are handled. Basically an exception can be

handled in one of three ways, it can be ignored, it can be corrected or it can be completely reworked. This is of interest because not only is something being done to the work but also some actor has to make the decision as to what is done. For example, is that decision being made by the 2nd Lieutenant on the ground where the exception is occurring or is the 2nd Lieutenant communicating back to the JTF staff (or maybe even the commander) for direction? This is a key concept. If the decision is being made right on the spot then centralization is low and it will not effect the speed of the information flow drastically but coordination may decrease. On the other hand if the decision is being sent up the hierarchy, as a centralized organization would do, it not only slows down the speed of the decision being made but it also creates some vulnerable node/links. By no means is centralization a bad thing for an organization for as *Organizational Consultant* illustrates that the greater the hostility and equivocality in an environment the more the need for centralization to deal with that hostility and equivocality. On the other hand, these vulnerable node/links can be exploited to the extent that enough exceptions are generated that the centralized structure literally becomes paralyzed because exceptions are being generated faster than they can be handled.

2. The Specifics of the Attacks

In *VDT* each actor has a skill set associated with them. These skill sets are completely definable by the user and the skill sets have an experience factor associated with them; high, medium or low. For example the LT_O has medium logistics and management skills. Also, each activity has list of required skills, for example LT_start

requires logistics and management skills. Each activity also has a requirement complexity, a solution complexity and a degree of uncertainty. For example, LT_start has a requirement complexity of medium, a solution complexity of medium and a degree of uncertainty of medium. The IW attacks are simulated by adjusting these variables, either decreasing the actor skill set or increasing the activity requirement complexity, solution complexity and uncertainty.

As an example of how *VDT* can be used to simulate an IW attack, the configuration was modified and a base run was conducted. After the establishment of the base (which was calculated at 5645 units) an attack was conducted individually on communications, PSYOP, sea transport, communications officer and the ground component commander in the humanitarian scenario.

An IW attack on the communications, or sea transport is simulated by increasing their requirement complexity, solution complexity and uncertainty. For example if the opponent can mine the waters, as discussed earlier, then that would drive the requirement and solution complexity up to high because personnel who are skilled at mine hunting and operating in mine infested water will now be required. Certainly the uncertainty would also increase to high if the waters are mined.

An attack on the communications officer or ground component commander is simulated by either increasing the requirement and solution complexities or decreasing the actor skill levels. For example if the opponent could take the communications officer or the ground component commander hostage than the CJTF would have to replace them and since the replacement would be new to the job thrust into the middle of an operation

then there skill set would be low.

One method of creating a PSYOP attack is generated by increasing the uncertainty of the activities. This could be accomplished by the earlier threat of the enemy planning to take all of the medical personnel hostage. The result, besides the medical personnel being moved off-shore, would be to increase the uncertainty to high of every activity because now the commander is not sure if the enemy will attempt to take other personnel hostage.

When the models are run the actual numbers themselves are not important, what is important is the relative comparison between the individual attacks incorporated in each model.

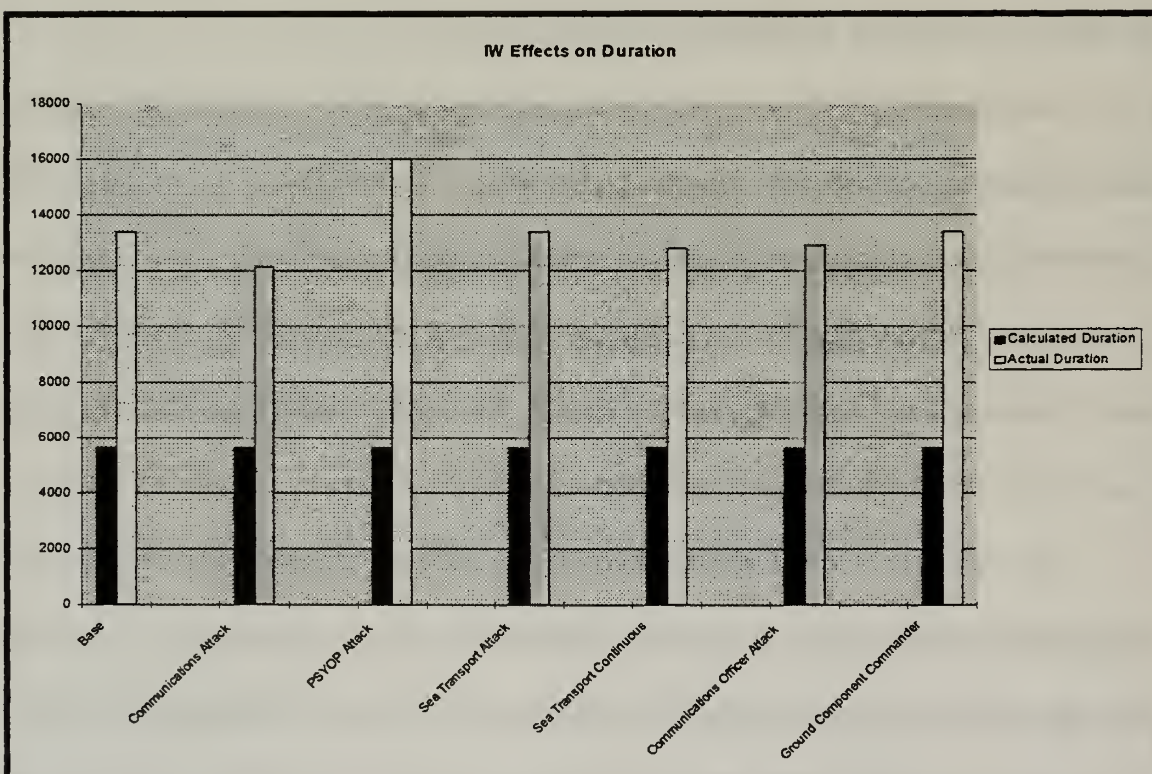


Figure 7. Comparison of various IW attacks on work duration

3. The Results of the IW Attacks

As you can see from Figure 7 the altering of the variables had a significant impact over the base calculation. As for the relative comparison it is obvious that the most effective attack would be the PSYOP attack when compared to the other IW attacks. To produce this data seven simulations were required; the base simulation and then six attack simulations. The output data, namely the total duration, was then captured in a spreadsheet which produced the graphic comparison for the commanders decision. Once the base configuration is established and entered into *VDT* (no trivial matter) it is relatively easy to manipulate data and explore different drivers (an example of a driver would be requirement or solution complexity) effect the duration.

The commander could ask the *VDT* operator to simulate different variables and since the base configuration is already created the operator would be able to rapidly respond to the commanders wishes. This is a useful feature because the commander can easily use *VDT* every cycle of the OODA Loop. If something in the base configuration drastically changes, for instance all ground operations are eliminated, with one click of the mouse *VDT* can now represent the new configuration.

E. CONCLUSION

VDT has proven to be a tremendous advantage to modeling information flow and decision processes in an organization. It has proven capable of identifying critical node/links and what the advantages can potentially be if the commander decides to exploit those node/links. It has demonstrated the value of measuring one form of IW attack against another form, but in the author's opinion one of the most important

benefits is not an output of *VDT*.

When using *VDT* it forces the user to clearly understand how the information is flowing and how the decision processes are being handled in an organization. Fundamentally the use of *VDT* forces a structured analysis of the workflow. This structured analysis allows the software user to clearly understand the opponent and the opponents organization and this insight is invaluable.

VDT also has its limitations. The learning curve for VDT is extremely steep and it is made even more difficult by the lack of documentation. Essentially a new user must resort to the trial and error method to learn *VDT* if there is no access to an experienced user.

VDT , in its current version, is also computer resource intensive. Granted, it runs on a personal computer, but it requires at least a 586 processor operating at 120 Mhz or greater with 32 Megabytes of RAM to offer the performance that would be required in a dynamic environment. As stated earlier it also requires the use of a color monitor to be able to view the interdependencies amongst the actors and tasks. Without the capability to understand these interdependencies *VDT* loses a tremendous amount of its versatility and the versatility that it does maintain is due to the fact that the *VDT* operator has a significant amount of skill using and editing the .opd file.

VDT, in its current version, is also very unstable and unforgiving. The software tends to terminate the program with the least little input error, hence once again the need for a highly skilled operator. And when *VDT* terminates the program due to an error it seizes control of all of the computer resources forcing a complete reboot of the system to

facilitate a recovery. *VDT* is unforgiving in that if it terminates a program due to an input error it will not allow that .opd file to be opened again. While this guarantees that no single .opd file will be responsible for more than one error it does slow down the learning process of the organization.

The author devoted a great deal of time to installing and configuring *VDT* to get it to run properly and thus there was not the opportunity to analyze numerous models. The limitation that this produces with this thesis is that there are no concrete results to demonstrate that *VDT* is the proper software to use to model decision processes. What has been demonstrated though is that it is indeed feasible to model decision processes and hence there is justification to explore this area more thoroughly.

VII. SUMMARY

A. THESIS SUMMARY

In this thesis the author examines the modeling of organizational decision processes for determining vulnerabilities to Information Warfare (IW). In order to model IW the commander must first understand IW and the concept of command and control. The concept of command and control includes organizational decision processes and how the decision processes allow an organization to adapt to its environment. Environmental adaptation is essential for an organization to survive. To understand how an organization adapts to its environment, the commander needs to understand the notions of situation fit, design parameter fit, how they can be altered and how they are interrelated by contingency fit. Briefly examined are the qualities that are desirable for a computer model to simulate and analyze organizational configurations and organizational decision processes. The thesis then models a hypothetical organization to assess its organizational configuration and organizational decision processes. Lastly, the organizational decision processes that could be modeled to understand the susceptibilities to IW attack are examined.

Having understood and accepted the importance of being able to model organizational configurations and organizational decision processes could go a long way in assisting the commander to understand his/her own organization and the opponent's organization including the strengths and weaknesses of each. Unfortunately, the state-of-the-art of computational modeling for organizational configuration and organizational

decision processes is problematic due to the fact that it is not user friendly. There is currently no military efforts in this direction, so there is a need to apply commercial civilian sector software to the problem. Additionally, this application was found to be less than satisfactory due to the fact that it was not user friendly and not stable enough of a software platform for a "non-expert" to use and thus the commander is only slightly better off than before. Though the state of computational modeling is less than desirable the commander is provided the tools to understand what variables, situation fit and design parameter fit combining properly to produce a total fit, that are necessary for an organization to adapt to its environment. The knowledge that these tools gives the commander allows the formation of a mental model of what is necessary and what variable effect what other variables.

The approaches outlined in Chapter V and VI demonstrate that it is possible to model organizational configuration and decision systems. They illustrate that there is some potential value to the commander in performing this modeling. However, in order for these efforts to reach fruition, considerable resources will be required to make the software user friendly and a stable enough platform that a non-expert can use it efficiently.

1. Further Research

The study of organizational configuration and organizational decision processes is growing at a remarkable rate in the mid 1990s due to the corporate need to downsize and increase efficiency. The DoD, during this time of "rightsizing" is being tasked with additional missions while at the same time seeing their end-strength and budgets decline.

They are being asked to do more with less and thus they need every advantage that they can get. The effort to model organizational configurations and decision processes can only help an already over-tasked commander. This author has only scratched the surface in regards to modeling organizational configurations and decision process. For further research in this area the following recommendations are made:

- A migration of *Organizational Consultant* to a Windowed environment to assist in user friendliness;
- A "militarized" version of *Organizational Consultant* such that it incorporates the differences between a military organization and a civilian commercial organization;
- The capability to diagram what input effects what output in *Organizational Consultant*;
- An exploration of whether the command would be better served with the addition of a "professional" organizational theorist on the staff instead of relying on software to resolve the issues;
- A robust version of *VDT* that has been software engineered to the point that a mistake on input will not crash the program and render the .opd file inoperable;
- A version of *VDT* that has software exception handling that will not allow the reader to perform an act that will cause an exception;
- A powerful and meaningful on-line help for the user of *VDT*;
- Some documentation that thoroughly discusses the behavioral matrix and its interactions with the .opd file for *VDT*;
- The search for alternative software programs to *VDT* that exhibit the same modeling characteristics as *VDT* but have none of the above short comings of *VDT*.

B. CONCLUDING REMARKS

The bottom line for any organization to survive is that it must understand its

environment and adapt to that environment. It would be useful for an overtasked and understaffed commander to model his/her organizational configuration and organizational decision making processes. However, at this stage of the process until the technology is further developed and refined that prospect is more of a hope than a promise.

The final test of any software attempting to model organizational configurations and organizational decision processes is whether the technology would match the expertise of a person knowledgeable about organizational theory and decision processes making recommendations to the commander and on that the jury is still out.

APPENDIX A: ORGANIZATIONAL CONSULTANT INPUT AND RESULTS

Current Configuration

1. **What is the organization's current organizational configuration?**
Answer: Functional. Typical missions include medical, communications, and transportation.
Certainty Factor - *90* - The country's leader may already have a divisional configuration in place.

Complexity

1. **How many different job titles are there?**
Answer: Moderate number. Vertically the JTF may be small but horizontally very large due to the large number of jobs. For example, every ship has concurrent duties that must be performed.
Certainty Factor - *75*
2. **What proportion of employees hold advanced degrees or have many years of specialized training?**
Answer: 21-50%. There is a lot of specialized training but not necessarily for the task at hand. For example, aviators trained to fly or troops trained for combat.
Certainty Factor - *100*
3. **How many vertical levels separate the chief executive from those employees working at the bottom of the organization?**
Answer: 6 to 8. We are considering the top of the organization to be the "executive" council which is comprised of the host nation representatives and the ambassador's staff. The bottom of the organization is the platoon (Navy division) which are the service providers.
Certainty Factor - *100.*
4. **What is the average number of levels for the organization?**
Answer: 3 to 5. These include the executive council, the JTF, the functional component, and the individual unit.
Certainty Factor - *100.*
5. **Including the main center, how many geographic locations are there where organization members are employed?**
Answer: 3 to 5. Members will primarily be at the ambassador staff center, the crisis center, the communications center, or the airport.
Certainty Factor - *100.*

6. **What is the average distance of these outlying units from the organization's main center?**
Answer: 11 to 100 miles. Average distance of these centers should be relatively close because the island is fairly small and since the troops will be living aboard ship, they cannot be much further.
Certainty Factor - *100.*
7. **What proportion of the organization's total work force are located at these separate units?**
Answer: less than 10%. These are the people that are not living aboard ship.
Certainty Factor - *100.*

Formalization

1. **Written job descriptions available for?**
Answer: all employees, including senior management. Everyone in the Navy has a job description.
Certainty Factor - *77.* Factor is reduced because the job descriptions may not be for the task at hand.
2. **Where written job descriptions exist, how closely are employees supervised to ensure compliance with standards set in the job description?**
Answer: moderately close. Certain standards have close adherence, for example crew rest for pilots. Other standards are followed loosely, for example driving a truck.
Certainty Factor - *90.*
3. **How much latitude are employees allowed from standards?**
Answer: moderate amount. Lower ranks are allowed small amounts of latitude but at the Lieutenant level there are great amounts of latitude. Standard at the higher levels is to get the job done safely.
Certainty Factor - *100.*
4. **What percentage of nonmanagerial employees are given written operating instructions or procedures for their job?**
Answer: 81 to 100%. Most nonmanagerial jobs have specific procedures for operation. For example, there are written instructions for driving a truck.
Certainty Factor - *100.*
5. **Of those managerial employees given written instructions or procedures, to what extent are they followed?**
Answer: a great deal. The only reason for not following a written instruction or procedure would be for safety.
Certainty Factor - *100.*
6. **To what extent are supervisors and middle managers free from rules, procedures, and policies when they make decisions?**
Answer: little. Supervisors are rarely free from rules, procedures, and policy.
Certainty Factor - *100.*

7. **What percentage of all the rules and procedures that exist within the organization is in writing?**
Answer: 21 to 40%. Rules for flying, driving, etc. are well written but procedures for this operation are adhoc and mostly verbal.
Certainty Factor - *100.*

Centralization

1. **How much direct involvement does top management have in gathering the information they will use in making decision?**
Answer: Some. Top management in this case consists of the executive council that includes the ambassador's staff. They set priorities, such as who is participating and at what level. Some of the information comes from the host nation through the ambassador's staff.
Certainty Factor - *80.* The certainty factor was reduced in this case because of the ambiguity in the significance versus the amount of information. Not a lot of information comes through the staff but it tends to have a higher importance.
2. **To what degree does top management participate in the interpretation of the information input?**
Answer: greater than 80%. This is the job of the executive council.
Certainty Factor - *100.*
3. **To what degree does top management directly control execution of a decision?**
Answer: 0 to 20%. The executive council sets the priorities and marching orders. This just sets the mission, it does not set the execution.
Certainty Factor - *100.*
4. **How much discretion does the typical middle manager have over establishing his or her budget?**
Answer: unknown/no answer. Middle manager would be the ground force commander or someone at that level. This budget may be established for the commander but in this case it may be different. The military commander is paid for working 24 hours a day and assets are usually provided as determined by an even higher level than our organization considers. (Congress)
Certainty Factor - *100.*
5. **How much discretion does the typical middle manager have over determining how his or her unit will be evaluated?**
Answer: Some. The commander writes his own fitness reports and forwards awards to his command to a higher level but the decision would happen at a higher level.
Certainty Factor - *100.*

6. **How much discretion does the typical middle manager have over hiring and firing personnel?**
Answer: None. The answer to this question is more of a statement of displeasure of one of the seemingly unfortunate "facts of life" in the military. The middle manager may move people in his/her command but actual firing is very difficult. A typical perception in the military is that if a troop does not work out, it is the fault of the leader. In order to fire someone from the military, very gross negligence must occur. For example, drug use. If a troop doesn't do the job well, poor evaluations result that may or may not lead to the troop being released from active duty.
Certainty Factor - *100.*
7. **How much discretion does the typical middle manager have over personnel rewards (i.e., salary increases and promotions)?**
Answer: Little. Salary increases are determined by advancement. Good evaluations help in advancement but other factors influence this more (advancement exams).
Certainty Factor - *70.* Factor is reduced because rewards in the military may come in other forms that the commander can control. Such as Sailor of the Quarter, or liberty passes. Are these really significant rewards?
8. **How much discretion does the typical middle manager have over purchasing equipment and supplies?**
Answer: Little. For the period of this operation, little can be done about changing what is already in the system. The commander could buy from the economy but this cannot be counted on due to the nature of the disaster.
Certainty Factor - *80%.* Factor reduced because the commander may or may not be able to purchase some things from the local economy in this situation.
9. **How much discretion does the typical middle manager have over establishing a new project of program?**
Answer: None. The executive council would decide on new projects.
Certainty Factor - *70.* Factor reduced because the middle manager may have new project denial authority. This isn't establishing a new project but is eliminating a new project. The commander could do this for various reasons, such as safety, lack of assets, common sense, etc.
10. **How much discretion does the typical middle manager have over how work exceptions are to be handled?**
Answer: Some. The commander may be able to modify his/her product (service) in order to get the job done.
Certainty Factor - *90.* Factor reduced slightly because product modification may or may not handle work exceptions.

Size

1. **How many employees does the organization have?**
Answer: 7500. This is the best guess that includes ships, staffs, and other experts.
Certainty Factor - *60.*

Age/Ownership

1. **How old is the organization?**
Answer: Young. The disaster just happened; therefore, by definition.
Certainty Factor - *100.*

2. **What kind of ownership does the organization have?**
Answer: Public/State owned. The military answers to and are funded by the public.
Certainty Factor - *100.*

Diversity

1. **Does the organization have many different products?**
Answer: Few. Products are communications, transportation, and medical typically.
Certainty Factor - *100.*
2. **Does the organization operate in many different markets?**
Answer: Few. The only customer is the host nation.
Certainty Factor - *100.*
3. **Does the organization operate in more than one country? If yes, is the activity level abroad greater than 25%?**
Answer: No. Host country operation only.
Certainty Factor - *100.*
4. **Does the organization have many different products in the foreign market?**
Answer: None.
Certainty Factor - *80.* Factor reduced because the applicability of this question is not understood for this organization.

Technology

1. **What is the major activity of the organization?**
Answer: Service. This organization provides communication, transportation, and medical services.
Certainty Factor - *100.*
2. **What kind of technology does the organization have?**
Answer: Specialized customer oriented service.
Certainty Factor - *100.*
3. **Does the organization have a routine technology?**
Answer: Yes. These missions are done all the time in combat.
Certainty Factor - *80.* The missions aren't usually done in this type of situation.
4. **Is the technology divisible?**
Answer: Some. Medical service can be broken into immediate care, preventative care, etc. Transportation can be land, sea, air.
Certainty Factor - *100.*

5. **Does the organization have a strong or weak dominant technology?**
Answer: Average.
Certainty Factor - *50.* Applicability of this question to this situation is not understood.
6. **Does the organization use or plan to use an advanced information system?**
Answer: Yes. The military command and control communication system is considered advanced.
Certainty Factor - *100.*

Environment

1. **Is the organizational environment simple or complex?**
Answer: Complex.
Certainty Factor - *80.* Factor reduced due to the questionable degree of complexity.
2. **What is the level of uncertainty of the environment?**
Answer: Low. Everyone understands what happened in this situation and to what degree.
Certainty Factor - *80.* Even though the environment should be unambiguous, sometimes it may move to Moderate uncertainty.
3. **Is the equivocality of the environment low or high?**
Answer: Low. Everyone understands what happened in this situation and what is happening.
Certainty Factor - *100.*
4. **Is the organizational environment hostile?**
Answer: Low. We are the only ones that would take the job.
Certainty Factor - *100.*

Management Profiles

1. **Top management may prefer to make most of the decisions themselves; or they may prefer to delegate numerous decisions to other managers (i.e., greater preference for decentralization). What kind of decisions does top management prefer to make?**
Answer: Both general and some operational decisions. The executive council may make some operational decisions like this NGO will do this to this extent.
Certainty Factor - *100.*
2. **Top management may prefer to make long-term decisions or short-time decisions. What kind of decisions does top management prefer to make?**
Answer: Short-time Decisions. This operation is limited to 30 days.
Certainty Factor - *100.*

3. **Top management may prefer to use very detailed or very aggregate information when making decisions. What level of detail of information does top management prefer to use when making decisions?**
Answer: Very aggregate. Usually a staff provides a short report to the council.
Certainty Factor - *100.*
4. **Top management may prefer to be proactive in its thinking, anticipate future events and take pre-emptive action. It may be reactive; wait and see and then act. What is top management's preference on taking action?**
Answer: Some proactive, some reactive.
Certainty Factor - *100.*
5. **Top management may be risk averse in its decision making, or it may have a preference to assume risk. What is top management's attitude towards risk?**
Answer: Risk neutral.
Certainty Factor - *100.*
6. **Top management may prefer to manage through ex ante motivation or ex post control techniques. What kind of motivation and control does top management prefer?**
Answer: Combination of motivation and control. Sometimes the council may just tell the commanders what to do.
Certainty Factor - *100.*

Strategy Factors

1. **Does the organization have a high or low capital requirement?**
Answer: Medium.
Certainty Factor - *100.*
2. **Does the organization have high or low product innovation?**
Answer: High. This is a new product for the military.
Certainty Factor - *100.*
3. **Does the organization have a high or low process innovation?**
Answer: Low. The product will be produced in the same manner that we conduct combat operations.
Certainty Factor - *100.*
4. **Does the organization have a high or low concern for quality?**
Answer: High.
Certainty Factor - *100.*
5. **How is the organization's price level compared to its competitors?**
Answer: Unknown/no answer. Doesn't apply.
Certainty Factor - *100.*

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Version 5.1-E

REPORT SUMMARY

INPUT DATA SUMMARY

The description below summarizes and interprets your answers to the questions about your organization and its situation. It states your answers concerning the organization's current configuration, complexity, formalization, and centralization. Your responses to the various questions on the contingencies of age, technology, environment, management style, and strategy factors are also given. The write-up below summarizes the input data for the analysis.

The Organization has a functional configuration.
The Organization has a moderate number of different jobs.
Of the employees at The Organization 21 to 50 % have an advanced degree or many years of special training.
The Organization has 6 to 8 verticals levels separating top management from the bottom level of the organization.
The mean number of vertical levels is 3 to 5.
The Organization has 3 to 5 separate geographic locations.
The Organization's average distance of these separate units from the organization's headquarters is 11 to 100 miles.
Less than 10 % of The Organization's total workforce is located at these separate units.
Job descriptions are available for all employees, including senior management.
Where written job descriptions exist, the employees are supervised moderately closely to ensure compliance with standards set in the job description.
The employees are allowed to deviate a moderate amount from the standards.
81 to 100 % of nonmanagerial employees are given written operating instructions or procedures for their job.
The written instructions or procedures given are followed to a great extent.
Supervisors and middle managers are to a little extent free from rules, procedures, and policies when they make decisions.
21 to 40 % of all the rules and procedures that exist within the organization are in writing.
Top Management is to some extent involved in gathering the information they will use in making decisions.
Top management participates in the interpretation of more than 80 % of the information input.
Top management directly controls 0 to 20 % of the decisions executed.
The typical middle manager has some discretion over how his/her unit will be evaluated.
The typical middle manager has no discretion over the hiring and firing of personnel.
The typical middle manager has little discretion over personnel rewards - (i.e., salary increases and promotions)
The typical middle manager has little discretion over purchasing equipment and supplies.
The typical middle manager has no discretion over establishing a new project or program.
The typical middle manager has some discretion over how work exceptions are to be handled.
The Organization has 7500 employees.
The Organization's age is young.
The Organization's ownership status is public.
The Organization has few different products.
The Organization has few different markets.
The Organization only operates in one country.
The Organization has no different products in the foreign market.
The Organization's major activity is categorized as service.
The Organization has a specialized customer-oriented service technology.
The Organization has a routine technology.
The Organization's technology is somewhat divisible.
The Organization's technology dominance is average.
The Organization has either planned or already has an advanced information system.
The Organization's environment is complex.
The uncertainty of The Organization's environment is low.
The Organization's environment has a low hostility.
The equivocality of the environment is low.
Top management prefers to make resource allocations and detailed operating decisions.
Top management primarily prefers to make short-time decisions.
Top management has a preference for very aggregate information when making decisions.
Top management has a preference for some proactive actions and some reactive actions.

Top management is risk neutral.
Top management has a preference for a combination of motivation and control.
The Organization operates in an industry with a medium capital requirement.
The Organization has a high product innovation.
The Organization has a low process innovation.
The Organization has a high concern for quality.
The Organization's price level is undetermined relative to its competitors.

THE SIZE OF THE ORGANIZATION

The size of the organization - large, medium, or small - is based upon the number of employees, adjusted for their level of education or technical skills.

Based on the answers you provided, it is most likely that your organization's size is large (cf 60).

Between 21 and 50 % of the people employed by The Organization have a high level of education. Adjustments are made to this effect.

The adjusted number of employees is greater than 2,000 and The Organization is categorized as large.

MANAGEMENT STYLE

The level of management's microinvolvement in decision making is the summary measure of management style. Leaders have a low preference for microinvolvement; managers have a high preference for microinvolvement.

Based on the answers you provided, it is most likely that your management profile has a medium preference for microinvolvement (cf 86).

The management of The Organization has a preference for letting some decisions be made by other managers. This will lead toward a medium preference for microinvolvement. The management of The Organization has a preference for taking actions on some decisions and being reactive toward others. This will lead toward a medium preference for microinvolvement. Management is risk neutral. This is one of the characteristics of a manager with a medium preference for microinvolvement. Management has a preference for using both motivation and control to coordinate the activities, which leads toward a medium preference for microinvolvement.

THE STRATEGY OF THE ORGANIZATION

The organization's strategy is categorized as one of either prospector, analyzer with innovation, analyzer without innovation, defender, or reactor. These categories follow Miles and Snow's typology. Based on your answers, the organization has been assigned to a strategy category. This is a statement of the current strategy; it is not an analysis of what is the best or preferred strategy for the organization.

Based on the answers you provided, it is most likely that your organization's strategy is a defender strategy (cf 69).
It could also be:
- an analyzer with innovation (cf 69).
- an analyzer without innovation (cf 67).

The Organization has few products. It needs to defend these products well in the marketplace. Viability depends on being successful with these limited activities. The Organization has a routine technology. Consequently, new products for new customers are less likely to be possible. It needs to defend its position for the technology it has or copy well-known products or markets. With a concern for high quality a defender strategy is a likely strategy for The Organization.

The high requirement for product innovation requires either a prospector or an analyzer with innovation strategy. An organization with a medium capital investment is likely to

have some capabilities rather fixed, but can also adjust. The analyzer with innovation which seeks new opportunities but also maintains its profitable position is appropriate. With a concern for high quality an analyzer with innovation strategy is a likely strategy for The Organization. With top management preferring a medium level of micro involvement top management wants some influence. This can be obtained via control over current operations. Product innovation should be less controlled. The strategy is therefore likely to be analyzer with innovation.

The capital requirement of The Organization is not high, which is consistent with an analyzer without innovation strategy. With a very routine technology, new products for new customers are not very likely, although the firm can copy a few products. Therefore, strategy is likely to be analyzer without innovation. With a concern for high quality an analyzer without innovation strategy is a likely strategy for The Organization.

THE ORGANIZATION'S CHARACTERISTICS

Based on your answers, the organization's complexity, formalization, and centralization have been calculated. This is the current organization. Later in this report, there will be recommendations for the organization.

The current organizational complexity is medium (cf 75).

The current horizontal differentiation is medium (cf 75).

The current vertical differentiation is medium (cf 100).

The current spatial differentiation is low (cf 100).

The current centralization is medium (cf 70).

The current formalization is high (cf 77).

The current organization has been categorized with respect to formalization, centralization, and complexity. The categorization is based on the input you gave and does not take missing information into account.

SITUATION MISFITS

A situation misfit is an unbalanced situation among the contingency factors of management style, size, environment, technology, and strategy.

There are situation misfits (cf 100).

The Organization has both a routine technology and a high requirement for product innovation. This may cause problems!

When many factors in the environment affect the organization, it may make it is difficult for a defender like The Organization to protect what it does and also difficult to protect its established market position. Therefore, the defender strategy is not appropriate!

THE RECOMMENDED ORGANIZATION

Based on your answers about the organization, its situation, and the conclusions with the greatest certaity factor from the analyses above Organizational Consultant has derived recommendations for the organization's configuration, complexity, formalization, and centralization. There are also recommendations for coordination and control, the appropriate media richness for communications, and incentives. More detailed recommendations for possible changes in the current organization are also provided.

The most likely configuration that best fits the situation has been estimated to be a

functional configuration (cf 69).
It is certainly not:
- an adhocracy (cf -77).

For a large organization with only few products, the functional configuration is recommended.

When the equivocality of The Organization's environment is not high and the organizational complexity is not low, the configuration should be functional. A functional configuration is usually required when the strategy is defender.

The Organization should have a structure somewhat similar to a machine-bureaucracy.

When the technology is very routine, the configuration cannot be an ad hoc configuration because it will not be able to operate!

The recommended degree of organizational complexity is medium (cf 61). The Organization has a defender strategy, which generally leads towards a medium to high organizational complexity. A defender needs cost efficiency, and that can be obtained through specialization. Large public organizations should have medium to high organizational complexity. When the uncertainty of The Organization's environment is low, the organizational complexity should neither be very low nor very high so that The Organization will be able to react quickly when the environment changes. Top management of The Organization has a preference for a medium level of microinvolvement, which drives the organizational complexity towards medium. Because The Organization has an advanced information system, organizational complexity can be greater than it could otherwise.

The recommended degree of formalization is high (cf 57). When the organization is in the service industry and it does have a routine technology, its formalization should be higher than if it had been in the manufacturing industry. When the organization uses an advanced information system, formalization should be high. The Organization has a defender strategy, which generally requires a high formalization. A defender needs cost efficiency, and that can be obtained through formalization. Large organizations should have high formalization. Organizations with routine technology should have high formalization.

The recommended degree of centralization is medium (cf 55).
There is evidence against it should be:
- low (cf -18).

When the organization is large and has a technology that is routine, then it is very likely that centralization should be medium. When many factors in the environment affect the organization but only very few of these variables are known, and the values of these known variables are known with a high degree of certainty, centralization should be medium. Medium centralization is recommended when top management has neither a great desire nor very little desire for microinvolvement. Because The Organization has an advanced information system, centralization can be greater than it could otherwise.

The recommended degree of horizontal differentiation is high (cf 41).

The recommended degree of vertical differentiation is medium (cf 56).

The Organization's span of control should be wide (cf 40).
Since The Organization has a routine technology, it should have a wide span of control.

The Organization should use media with low media richness (cf 100).

The information media that The Organization uses should provide a small amount of information (cf 70).
The media used should also provide
- a moderate amount of information (cf 70).

Incentives should be based on procedures (cf 91).

The Organization should use planning as means for coordination and control (cf 44).
It should also use
- rigid rules (cf 44).
- rules (cf 44).

- procedures (cf 44).

Since The Organization is not small and has a routine technology, coordination and control should be obtained via rules and planning, and media with low richness and a small amount of information can be used. Incentives should be based on process. With low equivocality, low uncertainty, and high complexity in The Organization's environment, coordination and control should be rules and procedures. A moderate amount of information must be considered, although it need not be rich for this low uncertainty and low equivocality environment. Incentives should be based on procedure, thus focusing on performing activities well. Top management should use staff for detailed planning. Numerous rules are likely to be necessary.

The members of the organization The Organization should be theory X type people (cf 55). When the top management of The Organization has a high or medium preference for microinvolvement, when formalization is high and when centralization is medium or high, the members of the organization should be Theory X type people.

ORGANIZATIONAL MISFITS

Organizational misfits compares the recommended organization with the current organization.

There are no organizational misfits (cf 100).

No organizational misfits encountered.

END

APPENDIX B: VDT INPUT OPD FILE

```
%==========================================================
%
%  Pretty.opd: An OPD file for application Pretty
%
%===========================================================


%-------------------- Object Declarations --------------------

(Application Pretty)

(VDTApp vdtPretty)
(Activities Med_ops)
(Activities Comm_end)
(Activities Comm_cont)
(Activities Comm_start)
(Activities Air_ops)
(Activities ST_end)
(Activities ST_cont)
(Activities ST_start)
(Activities F_ExecutiveProj)
(Activities S_ExecutiveProj)
(Activities LT_start)
(Activities LT_cont)
(Activities LT_end)
(Successor SuccessorMed_opsLT_end)
(Successor SuccessorLT_startMed_ops)
(Successor SuccessorST_startComm_start)
(Successor SuccessorComm_endST_end)
(Successor SuccessorComm_contComm_end)
(Successor SuccessorComm_startComm_cont)
(Successor SuccessorAir_opsLT_end)
(Successor SuccessorLT_startAir_ops)
(Successor SuccessorST_endF_ExecutiveProj)
(Successor SuccessorST_startST_cont)
(Successor SuccessorS_ExecutiveProjST_start)
(Successor SuccessorST_contST_end)
(Successor SuccessorST_startLT_start)
(Successor SuccessorLT_startLT_cont)
(Successor SuccessorLT_contLT_end)
(Successor SuccessorLT_endST_end)
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(Predecessor PredecessorComm_startST_start)
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(FailureDependent FailureDependentLT_contAir_ops)
(FailureDependentOf FailureDependentOfLT_contST_cont)
(FailureDependentOf FailureDependentOfLT_contComm_cont)
```

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(FailureDependentOf FailureDependentOfAir_opsLT_cont)
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(Actors MedO)
(Actors CommO)
(Actors LT_O)
(Actors ST_O)
(Actors ACC)
(Actors GCC)
(Actors NCC)
(Actors CJTF)
(Actors ExecutiveTeam_PM)
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(Supervise SuperviseGCCMedO)
(Supervise SuperviseGCCCommO)
(Supervise SuperviseGCCLT_O)
(Supervise SuperviseNCCST_O)
(Supervise SuperviseCJTFACC)
(Supervise SuperviseCJTFGCC)
(Supervise SuperviseCJTFNCC)
(Supervise SuperviseExecutiveTeam_PMCJTF)
(SupervisedBy SupervisedByAT_OACC)
(SupervisedBy SupervisedByMedOGCC)
(SupervisedBy SupervisedByCommOGCC)
(SupervisedBy SupervisedByLT_OGCC)
(SupervisedBy SupervisedByST_ONCC)
(SupervisedBy SupervisedByACCCJTF)
(SupervisedBy SupervisedByGCCCJTF)
(SupervisedBy SupervisedByNCCCJTF)
(SupervisedBy SupervisedByCJTFExecutiveTeam_PM)
(ResponsibleFor ResponsibleForMedOMed_ops)
(ResponsibleFor ResponsibleForCommOComm_end)
(ResponsibleFor ResponsibleForCommOComm_cont)
(ResponsibleFor ResponsibleForCommOComm_start)
(ResponsibleFor ResponsibleForLT_OLT_end)
(ResponsibleFor ResponsibleForLT_OLT_cont)
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(ResponsibleFor ResponsibleForST_OST_end)
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(ResponsibleFor ResponsibleForExecutiveTeam_PMS_ExecutiveProj)
(ResponsibleFor ResponsibleForST_OST_cont)
(ResponsibleFor ResponsibleForLT_OLT_start)
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(ResponsibleBy ResponsibleByComm_endCommO)
(ResponsibleBy ResponsibleByComm_contCommO)
(ResponsibleBy ResponsibleByComm_startCommO)
(ResponsibleBy ResponsibleByLT_endLT_O)
(ResponsibleBy ResponsibleByLT_contLT_O)
(ResponsibleBy ResponsibleByAir_opsAT_O)
(ResponsibleBy ResponsibleByST_endST_O)
(ResponsibleBy ResponsibleByST_startST_O)
(ResponsibleBy ResponsibleByF_ExecutiveProjExecutiveTeam_PM)
(ResponsibleBy ResponsibleByS_ExecutiveProjExecutiveTeam_PM)
(ResponsibleBy ResponsibleByST_contST_O)
(ResponsibleBy ResponsibleByLT_startLT_O)
(Projects ExecutiveProj)
(Organizations ExecutiveTeam)

%-------------------- Object Definitions --------------------

(VDTApp vdtPretty
    :App                     Pretty
    :OPDFileName             "Pretty"
    :Teams                   ExecutiveTeam
    :Projects                ExecutiveProj
)
(Activities Med_ops
    :Uncertainty             Medium
    :SolutionComplexity              Medium
    :RequirementComplexity   Medium
    :CraftRequirement        Medical
    :Project                 ExecutiveProj
    :WorkVolume                      10560
    :TaskSize                480
```

```
    :WorkVolumeUnit          "man-day"
    :X                       430
    :Y                       403
    :Name                    "Med_ops"
    :ResponsibleBy           ResponsibleByMed_opsMedO
    :FailureDependentOf              FailureDependentOfMed_opsComm_cont
    :ReciprocalWith          ReciprocalWithMed_opsLT_cont
    :ParentComponent         ProjectEditorImage
    :Predecessor             PredecessorMed_opsLT_start
    :Successor               SuccessorMed_opsLT_end
)
(Activities Comm_end
    :Uncertainty             Medium
    :SolutionComplexity              Medium
    :RequirementComplexity   Medium
    :CraftRequirement        Electrical
    :Project                 ExecutiveProj
    :WorkVolume                      960
    :TaskSize                96
    :WorkVolumeUnit          "man-day"
    :X                       505
    :Y                       454
    :Name                    "Comm_end"
    :ResponsibleBy           ResponsibleByComm_endCommO
    :ParentComponent         ProjectEditorImage
    :Predecessor             PredecessorComm_endComm_cont
    :Successor               SuccessorComm_endST_end
)
(Activities Comm_cont
    :Uncertainty             Medium
    :SolutionComplexity              Medium
    :RequirementComplexity   Medium
    :CraftRequirement        Electrical
    :Project                 ExecutiveProj
    :WorkVolume                      9120
    :TaskSize                480
    :WorkVolumeUnit          "man-day"
    :X                       357
    :Y                       447
    :Name                    "Comm_cont"
    :ResponsibleBy           ResponsibleByComm_contCommO
    :FailureDependent        FailureDependentComm_contLT_cont
FailureDependentComm_contMed_ops
    :ParentComponent         ProjectEditorImage
    :Predecessor             PredecessorComm_contComm_start
    :Successor               SuccessorComm_contComm_end
)
(Activities Comm_start
    :Uncertainty             Medium
    :SolutionComplexity              Medium
    :RequirementComplexity   Medium
    :CraftRequirement        Electrical
    :Project                 ExecutiveProj
    :WorkVolume                      1440
    :TaskSize                144
    :WorkVolumeUnit          "man-day"
    :X                       216
    :Y                       454
    :Name                    "Comm_start"
    :ResponsibleBy           ResponsibleByComm_startCommO
    :ParentComponent         ProjectEditorImage
    :Predecessor             PredecessorComm_startST_start
    :Successor               SuccessorComm_startComm_cont
)
(Activities Air_ops
    :Uncertainty             Medium
    :SolutionComplexity              Medium
    :RequirementComplexity   Medium
    :CraftRequirement        Flight
    :Project                 ExecutiveProj
    :WorkVolume                      10560
    :TaskSize                480
    :WorkVolumeUnit          "man-day"
    :X                       397
    :Y                       356
```

```
    :Name                      "Air_ops"
    :ResponsibleBy             ResponsibleByAir_opsAT_O
    :FailureDependentOf               FailureDependentOfAir_opsLT_cont
    :ReciprocalWith            ReciprocalWithAir_opsLT_cont
    :ParentComponent           ProjectEditorImage
    :Predecessor               PredecessorAir_opsLT_start
    :Successor                 SuccessorAir_opsLT_end
)
(Activities ST_end
    :Uncertainty               Medium
    :SolutionComplexity               Medium
    :RequirementComplexity     Medium
    :CraftRequirement          Amphibous
    :Project                   ExecutiveProj
    :WorkVolume                       1440
    :TaskSize                  144
    :WorkVolumeUnit            "man-day"
    :X                         631
    :Y                         269
    :Name                      "ST_end"
    :ResponsibleBy             ResponsibleByST_endST_O
    :ParentComponent           ProjectEditorImage
    :Predecessor               PredecessorST_endLT_end PredecessorST_endComm_end
PredecessorST_endST_cont
    :Successor                 SuccessorST_endF_ExecutiveProj
)
(Activities ST_cont
    :Uncertainty               Medium
    :SolutionComplexity               Medium
    :RequirementComplexity     Medium
    :CraftRequirement          Amphibous
    :Project                   ExecutiveProj
    :WorkVolume                       11520
    :TaskSize                  480
    :WorkVolumeUnit            "man-day"
    :X                         346
    :Y                         269
    :Name                      "ST_cont"
    :ResponsibleBy             ResponsibleByST_contST_O
    :FailureDependent          FailureDependentST_contLT_cont
    :ReciprocalWith            ReciprocalWithST_contLT_cont
    :ParentComponent           ProjectEditorImage
    :Predecessor               PredecessorST_contST_start
    :Successor                 SuccessorST_contST_end
)
(Activities ST_start
    :Uncertainty               Medium
    :SolutionComplexity               Medium
    :RequirementComplexity     Medium
    :CraftRequirement          Amphibious
    :Project                   ExecutiveProj
    :WorkVolume                       1440
    :TaskSize                  144
    :WorkVolumeUnit            "man-day"
    :X                         89
    :Y                         269
    :Name                      "ST_start"
    :ResponsibleBy             ResponsibleByST_startST_O
    :ParentComponent           ProjectEditorImage
    :Predecessor               PredecessorST_startS_ExecutiveProj
    :Successor                 SuccessorST_startComm_start SuccessorST_startLT_start
SuccessorST_startST_cont
)
(Activities F_ExecutiveProj
    :Uncertainty               Medium
    :SolutionComplexity               Medium
    :RequirementComplexity     Medium
    :CraftRequirement          NotSpecified
    :Project                   ExecutiveProj
    :WorkVolume                       480
    :TaskSize                  48
    :WorkVolumeUnit            "man-day"
    :X                         706
    :Y                         268
    :ResponsibleBy             ResponsibleByF_ExecutiveProjExecutiveTeam_PM
```

```
    :ParentComponent          ProjectEditorImage
    :Predecessor              PredecessorF_ExecutiveProjST_end
)
(Activities S_ExecutiveProj
    :Uncertainty              Medium
    :SolutionComplexity               Medium
    :RequirementComplexity    Medium
    :CraftRequirement         NotSpecified
    :Project                  ExecutiveProj
    :WorkVolume                       480
    :TaskSize                 48
    :WorkVolumeUnit           "man-day"
    :X                        8
    :Y                        269
    :ResponsibleBy            ResponsibleByS_ExecutiveProjExecutiveTeam_PM
    :ParentComponent          ProjectEditorImage
    :Successor                SuccessorS_ExecutiveProjST_start
)
(Activities LT_start
    :Uncertainty              Medium
    :SolutionComplexity               Medium
    :RequirementComplexity    Medium
    :CraftRequirement         Logistics
    :Project                  ExecutiveProj
    :WorkVolume                       1440
    :TaskSize                 144
    :WorkVolumeUnit           "man-day"
    :X                        195
    :Y                        321
    :Name                     "LT_start"
    :ResponsibleBy            ResponsibleByLT_startLT_O
    :ParentComponent          ProjectEditorImage
    :Predecessor              PredecessorLT_startST_start
    :Successor                SuccessorLT_startMed_ops SuccessorLT_startAir_ops
SuccessorLT_startLT_cont
)
(Activities LT_cont
    :Uncertainty              Medium
    :SolutionComplexity               Medium
    :RequirementComplexity    Medium
    :CraftRequirement         Logistics
    :Project                  ExecutiveProj
    :WorkVolume                       9600
    :TaskSize                 480
    :WorkVolumeUnit           "man-day"
    :X                        311
    :Y                        321
    :Name                     "LT_cont"
    :ResponsibleBy            ResponsibleByLT_contLT_O
    :FailureDependentOf               FailureDependentOfLT_contST_cont
FailureDependentOfLT_contComm_cont
    :FailureDependent         FailureDependentLT_contAir_ops
    :ReciprocalWith           ReciprocalWithLT_contAir_ops ReciprocalWithLT_contMed_ops
ReciprocalWithLT_contST_cont
    :ParentComponent          ProjectEditorImage
    :Predecessor              PredecessorLT_contLT_start
    :Successor                SuccessorLT_contLT_end
)
(Activities LT_end
    :Uncertainty              Medium
    :SolutionComplexity               Medium
    :RequirementComplexity    Medium
    :CraftRequirement         Logistics
    :Project                  ExecutiveProj
    :WorkVolume                       960
    :TaskSize                 96
    :WorkVolumeUnit           "man-day"
    :X                        512
    :Y                        321
    :Name                     "LT_end"
    :ResponsibleBy            ResponsibleByLT_endLT_O
    :ParentComponent          ProjectEditorImage
    :Predecessor              PredecessorLT_endMed_ops PredecessorLT_endAir_ops
PredecessorLT_endLT_cont
    :Successor                SuccessorLT_endST_end
```

```
)
(Successor SuccessorMed_opsLT_end
    :X1                       500
    :X2                       512
    :Y1                       418
    :Y2                       336
    :Inverse                  PredecessorLT_endMed_ops
    :Domain                   Med_ops
    :Range                    LT_end
    :ParentComponent          ProjectEditorImage
)
(Successor SuccessorLT_startMed_ops
    :X1                       265
    :X2                       430
    :Y1                       336
    :Y2                       418
    :Inverse                  PredecessorMed_opsLT_start
    :Domain                   LT_start
    :Range                    Med_ops
    :ParentComponent          ProjectEditorImage
)
(Successor SuccessorST_startComm_start
    :X1                       159
    :Type                     FinishToStart
    :X2                       216
    :Y1                       284
    :Y2                       469
    :Inverse                  PredecessorComm_startST_start
    :Domain                   ST_start
    :TimeLag                  0
    :Range                    Comm_start
    :ParentComponent          ProjectEditorImage
)
(Successor SuccessorComm_endST_end
    :X1                       575
    :X2                       631
    :Y1                       469
    :Y2                       284
    :Inverse                  PredecessorST_endComm_end
    :Domain                   Comm_end
    :Range                    ST_end
    :ParentComponent          ProjectEditorImage
)
(Successor SuccessorComm_contComm_end
    :X1                       427
    :X2                       505
    :Y1                       462
    :Y2                       469
    :Inverse                  PredecessorComm_endComm_cont
    :Domain                   Comm_cont
    :Range                    Comm_end
    :ParentComponent          ProjectEditorImage
)
(Successor SuccessorComm_startComm_cont
    :X1                       286
    :Type                     FinishToStart
    :X2                       357
    :Y1                       469
    :Y2                       462
    :Inverse                  PredecessorComm_contComm_start
    :Domain                   Comm_start
    :TimeLag                  0
    :Range                    Comm_cont
    :ParentComponent          ProjectEditorImage
)
(Successor SuccessorAir_opsLT_end
    :X1                       467
    :X2                       512
    :Y1                       371
    :Y2                       336
    :Inverse                  PredecessorLT_endAir_ops
    :Domain                   Air_ops
    :Range                    LT_end
    :ParentComponent          ProjectEditorImage
)
```

```
(Successor SuccessorLT_startAir_ops
    :X1                        265
    :X2                        397
    :Y1                        336
    :Y2                        371
    :Inverse                   PredecessorAir_opsLT_start
    :Domain                    LT_start
    :Range                     Air_ops
    :ParentComponent           ProjectEditorImage
)
(Successor SuccessorST_endF_ExecutiveProj
    :X1                        701
    :X2                        706
    :Y1                        284
    :Y2                        283
    :Inverse                   PredecessorF_ExecutiveProjST_end
    :Domain                    ST_end
    :Range                     F_ExecutiveProj
    :ParentComponent           ProjectEditorImage
)
(Successor SuccessorST_startST_cont
    :X1                        159
    :X2                        346
    :Y1                        284
    :Y2                        284
    :Inverse                   PredecessorST_contST_start
    :Domain                    ST_start
    :Range                     ST_cont
    :ParentComponent           ProjectEditorImage
)
(Successor SuccessorS_ExecutiveProjST_start
    :X1                        78
    :X2                        89
    :Y1                        284
    :Y2                        284
    :Inverse                   PredecessorST_startS_ExecutiveProj
    :Domain                    S_ExecutiveProj
    :Range                     ST_start
    :ParentComponent           ProjectEditorImage
)
(Successor SuccessorST_contST_end
    :X1                        416
    :X2                        631
    :Y1                        284
    :Y2                        284
    :Inverse                   PredecessorST_endST_cont
    :Domain                    ST_cont
    :Range                     ST_end
    :ParentComponent           ProjectEditorImage
)
(Successor SuccessorST_startLT_start
    :X1                        159
    :X2                        195
    :Y1                        284
    :Y2                        336
    :Inverse                   PredecessorLT_startST_start
    :Domain                    ST_start
    :Range                     LT_start
    :ParentComponent           ProjectEditorImage
)
(Successor SuccessorLT_startLT_cont
    :X1                        265
    :X2                        311
    :Y1                        336
    :Y2                        336
    :Inverse                   PredecessorLT_contLT_start
    :Domain                    LT_start
    :Range                     LT_cont
    :ParentComponent           ProjectEditorImage
)
(Successor SuccessorLT_contLT_end
    :X1                        381
    :X2                        512
    :Y1                        336
    :Y2                        336
```

```
    :Inverse                  PredecessorLT_endLT_cont
    :Domain                   LT_cont
    :Range                    LT_end
    :ParentComponent          ProjectEditorImage
)
(Successor SuccessorLT_endST_end
    :X1                       582
    :X2                       631
    :Y1                       336
    :Y2                       284
    :Inverse                  PredecessorST_endLT_end
    :Domain                   LT_end
    :Range                    ST_end
    :ParentComponent          ProjectEditorImage
)
(Predecessor PredecessorLT_endMed_ops
    :Inverse                  SuccessorMed_opsLT_end
    :Domain                   LT_end
    :Range                    Med_ops
    :InverseClass             Successor
)
(Predecessor PredecessorMed_opsLT_start
    :Inverse                  SuccessorLT_startMed_ops
    :Domain                   Med_ops
    :Range                    LT_start
    :InverseClass             Successor
)
(Predecessor PredecessorComm_startST_start
    :Type                     FinishToStart
    :Inverse                  SuccessorST_startComm_start
    :Domain                   Comm_start
    :TimeLag                  0
    :Range                    ST_start
    :InverseClass             Successor
)
(Predecessor PredecessorST_endComm_end
    :Inverse                  SuccessorComm_endST_end
    :Domain                   ST_end
    :Range                    Comm_end
    :InverseClass             Successor
)
(Predecessor PredecessorComm_endComm_cont
    :Inverse                  SuccessorComm_contComm_end
    :Domain                   Comm_end
    :Range                    Comm_cont
    :InverseClass             Successor
)
(Predecessor PredecessorComm_contComm_start
    :Type                     FinishToStart
    :Inverse                  SuccessorComm_startComm_cont
    :Domain                   Comm_cont
    :TimeLag                  0
    :Range                    Comm_start
    :InverseClass             Successor
)
(Predecessor PredecessorLT_endAir_ops
    :Inverse                  SuccessorAir_opsLT_end
    :Domain                   LT_end
    :Range                    Air_ops
    :InverseClass             Successor
)
(Predecessor PredecessorAir_opsLT_start
    :Inverse                  SuccessorLT_startAir_ops
    :Domain                   Air_ops
    :Range                    LT_start
    :InverseClass             Successor
)
(Predecessor PredecessorF_ExecutiveProjST_end
    :Inverse                  SuccessorST_endF_ExecutiveProj
    :Domain                   F_ExecutiveProj
    :Range                    ST_end
    :InverseClass             Successor
)
(Predecessor PredecessorST_contST_start
    :Inverse                  SuccessorST_startST_cont
```

```
    :Domain                    ST_cont
    :Range                     ST_start
    :InverseClass              Successor
)
(Predecessor PredecessorST_startS_ExecutiveProj
    :Inverse                   SuccessorS_ExecutiveProjST_start
    :Domain                    ST_start
    :Range                     S_ExecutiveProj
    :InverseClass              Successor
)
(Predecessor PredecessorST_endST_cont
    :Inverse                   SuccessorST_contST_end
    :Domain                    ST_end
    :Range                     ST_cont
    :InverseClass              Successor
)
(Predecessor PredecessorLT_startST_start
    :Inverse                   SuccessorST_startLT_start
    :Domain                    LT_start
    :Range                     ST_start
    :InverseClass              Successor
)
(Predecessor PredecessorLT_contLT_start
    :Inverse                   SuccessorLT_startLT_cont
    :Domain                    LT_cont
    :Range                     LT_start
    :InverseClass              Successor
)
(Predecessor PredecessorLT_endLT_cont
    :Inverse                   SuccessorLT_contLT_end
    :Domain                    LT_end
    :Range                     LT_cont
    :InverseClass              Successor
)
(Predecessor PredecessorST_endLT_end
    :Inverse                   SuccessorLT_endST_end
    :Domain                    ST_end
    :Range                     LT_end
    :InverseClass              Successor
)
(ReciprocalWith ReciprocalWithLT_contMed_ops
    :X1                        341
    :X2                        460
    :Y1                        336
    :Y2                        418
    :Inverse                   ReciprocalWithMed_opsLT_cont
    :Domain                    LT_cont
    :Range                     Med_ops
    :InverseClass              ReciprocalWith
    :ParentComponent           ProjectEditorImage
)
(ReciprocalWith ReciprocalWithMed_opsLT_cont
    :X1                        460
    :X2                        341
    :Y1                        418
    :Y2                        336
    :Inverse                   ReciprocalWithLT_contMed_ops
    :Domain                    Med_ops
    :Range                     LT_cont
    :ParentComponent           ProjectEditorImage
)
(ReciprocalWith ReciprocalWithST_contLT_cont
    :X1                        376
    :X2                        341
    :Y1                        284
    :Y2                        336
    :Inverse                   ReciprocalWithLT_contST_cont
    :Domain                    ST_cont
    :Range                     LT_cont
    :InverseClass              ReciprocalWith
    :ParentComponent           ProjectEditorImage
)
(ReciprocalWith ReciprocalWithLT_contST_cont
    :X1                        341
    :X2                        376
```

```
    :Y1                         336
    :Y2                         284
    :Inverse                    ReciprocalWithST_contLT_cont
    :Domain                     LT_cont
    :Range                      ST_cont
    :ParentComponent            ProjectEditorImage
)
(ReciprocalWith ReciprocalWithAir_opsLT_cont
    :X1                         427
    :X2                         341
    :Y1                         371
    :Y2                         336
    :Inverse                    ReciprocalWithLT_contAir_ops
    :Domain                     Air_ops
    :Range                      LT_cont
    :ParentComponent            ProjectEditorImage
)
(ReciprocalWith ReciprocalWithLT_contAir_ops
    :X1                         341
    :X2                         427
    :Y1                         336
    :Y2                         371
    :Inverse                    ReciprocalWithAir_opsLT_cont
    :Domain                     LT_cont
    :Range                      Air_ops
    :InverseClass               ReciprocalWith
    :ParentComponent            ProjectEditorImage
)
(FailureDependent FailureDependentST_contLT_cont
    :X1                         386
    :X2                         351
    :Y1                         284
    :Y2                         336
    :Inverse                    FailureDependentOfLT_contST_cont
    :Domain                     ST_cont
    :Range                      LT_cont
    :ParentComponent            ProjectEditorImage
)
(FailureDependent FailureDependentComm_contLT_cont
    :X1                         397
    :X2                         351
    :Y1                         462
    :Y2                         336
    :Inverse                    FailureDependentOfLT_contComm_cont
    :Domain                     Comm_cont
    :Range                      LT_cont
    :ParentComponent            ProjectEditorImage
)
(FailureDependent FailureDependentComm_contMed_ops
    :X1                         397
    :X2                         470
    :Y1                         462
    :Y2                         418
    :Inverse                    FailureDependentOfMed_opsComm_cont
    :Strength                   1
    :Domain                     Comm_cont
    :Range                      Med_ops
    :ParentComponent            ProjectEditorImage
)
(FailureDependent FailureDependentLT_contAir_ops
    :X1                         351
    :X2                         437
    :Y1                         336
    :Y2                         371
    :Inverse                    FailureDependentOfAir_opsLT_cont
    :Domain                     LT_cont
    :Range                      Air_ops
    :ParentComponent            ProjectEditorImage
)
(FailureDependentOf FailureDependentOfLT_contST_cont
    :Inverse                    FailureDependentST_contLT_cont
    :Domain                     LT_cont
    :Range                      ST_cont
    :InverseClass               FailureDependent
)
```

```
(FailureDependentOf FailureDependentOfLT_contComm_cont
    :Inverse                  FailureDependentComm_contLT_cont
    :Domain                   LT_cont
    :Range                    Comm_cont
    :InverseClass             FailureDependent
)
(FailureDependentOf FailureDependentOfMed_opsComm_cont
    :Inverse                  FailureDependentComm_contMed_ops
    :Strength                 1
    :Domain                   Med_ops
    :Range                    Comm_cont
    :InverseClass             FailureDependent
)
(FailureDependentOf FailureDependentOfAir_opsLT_cont
    :Inverse                  FailureDependentLT_contAir_ops
    :Domain                   Air_ops
    :Range                    LT_cont
    :InverseClass             FailureDependent
)
(Actors AT_O
    :SalaryRate                       50
    :Role                     ST
    :NumberOfParticipants     1
    :TaskExperience           Medium
    :Craft                    (Management Medium)
 (Flight Medium)

    :MemberOf                 ExecutiveTeam
    :X                        587
    :Y                        146
    :ResponsibleFor           ResponsibleForAT_OAir_ops
    :SupervisedBy             SupervisedByAT_OACC
    :ParentComponent          ProjectEditorImage
    :CenterX                  622
    :CenterY                  164
)
(Actors MedO
    :SalaryRate                       50
    :Role                     ST
    :NumberOfParticipants     1
    :TaskExperience           Medium
    :Craft                    (Management Medium)
 (Medical Medium)

    :MemberOf                 ExecutiveTeam
    :X                        477
    :Y                        160
    :ResponsibleFor           ResponsibleForMedOMed_ops
    :SupervisedBy             SupervisedByMedOGCC
    :ParentComponent          ProjectEditorImage
    :CenterX                  512
    :CenterY                  178
)
(Actors CommO
    :SalaryRate                       50
    :Role                     ST
    :NumberOfParticipants     1
    :TaskExperience           Medium
    :Craft                    (Management Medium)
 (Electrical Medium)

    :MemberOf                 ExecutiveTeam
    :X                        346
    :Y                        156
    :ResponsibleFor           ResponsibleForCommOComm_end ResponsibleForCommOComm_cont
ResponsibleForCommOComm_start
    :SupervisedBy             SupervisedByCommOGCC
    :ParentComponent          ProjectEditorImage
    :CenterX                  381
    :CenterY                  174
)
(Actors LT_O
    :SalaryRate                       50
    :Role                     ST
    :NumberOfParticipants     1
```

```
    :TaskExperience          Medium
    :Craft                   (Management Medium)
 (Logistics Medium)

    :MemberOf                ExecutiveTeam
    :X                       235
    :Y                       155
    :ResponsibleFor          ResponsibleForLT_OLT_end ResponsibleForLT_OLT_cont
ResponsibleForLT_OLT_start
    :SupervisedBy            SupervisedByLT_OGCC
    :ParentComponent         ProjectEditorImage
    :CenterX                 270
    :CenterY                 173
)
(Actors ST_O
    :SalaryRate                     50
    :Role                    ST
    :NumberOfParticipants    1
    :TaskExperience          Medium
    :Craft                   (Management Medium)
 (Amphibious Medium)

    :MemberOf                ExecutiveTeam
    :X                       95
    :Y                       157
    :ResponsibleFor          ResponsibleForST_OST_end ResponsibleForST_OST_cont
ResponsibleForST_OST_start
    :SupervisedBy            SupervisedByST_ONCC
    :ParentComponent         ProjectEditorImage
    :CenterX                 130
    :CenterY                 175
)
(Actors ACC
    :SalaryRate                     50
    :Role                    SL
    :NumberOfParticipants    1
    :TaskExperience          Medium
    :Craft                   (Flight Medium)
 (Management Medium)

    :MemberOf                ExecutiveTeam
    :X                       587
    :Y                       101
    :SupervisedBy            SupervisedByACCCJTF
    :Supervise               SuperviseACCAT_O
    :ParentComponent         ProjectEditorImage
    :CenterX                 622
    :CenterY                 119
)
(Actors GCC
    :SalaryRate                     50
    :Role                    SL
    :NumberOfParticipants    1
    :TaskExperience          Medium
    :Craft                   (Logistics Medium)
 (Management Medium)

    :MemberOf                ExecutiveTeam
    :X                       338
    :Y                       106
    :SupervisedBy            SupervisedByGCCCJTF
    :Supervise               SuperviseGCCMedO SuperviseGCCCommO SuperviseGCCLT_O
    :ParentComponent         ProjectEditorImage
    :CenterX                 373
    :CenterY                 124
)
(Actors NCC
    :SalaryRate                     50
    :Role                    SL
    :NumberOfParticipants    1
    :TaskExperience          High
    :Craft                   (Amphibious Medium)
 (Management High)

    :MemberOf                ExecutiveTeam
```

```
    :X                          97
    :Y                          105
    :SupervisedBy               SupervisedByNCCCJTF
    :Supervise                  SuperviseNCCST_O
    :ParentComponent            ProjectEditorImage
    :CenterX                    132
    :CenterY                    123
)
(Actors CJTF
    :SalaryRate                         50
    :Role                       SL
    :NumberOfParticipants       3
    :TaskExperience             Medium
    :Craft                      (Electrical Low)
 (Flight Low)
 (Logistics Low)
 (Amphibious Low)
 (Medical Low)
 (Management Medium)

    :MemberOf                   ExecutiveTeam
    :X                          335
    :Y                          55
    :SupervisedBy               SupervisedByCJTFExecutiveTeam_PM
    :Supervise                  SuperviseCJTFACC SuperviseCJTFGCC SuperviseCJTFNCC
    :ParentComponent            ProjectEditorImage
    :CenterX                    370
    :CenterY                    73
)
(Actors ExecutiveTeam_PM
    :SalaryRate                         50
    :Role                       PM
    :NumberOfParticipants       1
    :TaskExperience             Low
    :Craft                      (Management Medium)

    :MemberOf                   ExecutiveTeam
    :X                          332
    :Y                          3
    :ResponsibleFor             ResponsibleForExecutiveTeam_PMF_ExecutiveProj
ResponsibleForExecutiveTeam_PMS_ExecutiveProj
    :Supervise                  SuperviseExecutiveTeam_PMCJTF
    :ParentComponent            ProjectEditorImage
    :CenterX                    367
    :CenterY                    21
)
(Supervise SuperviseACCAT_O
    :X1                         622
    :X2                         622
    :Y1                         119
    :Y2                         164
    :Inverse                    SupervisedByAT_OACC
    :Domain                     ACC
    :Range                      AT_O
    :ParentComponent            ProjectEditorImage
)
(Supervise SuperviseGCCMedO
    :X1                         373
    :X2                         512
    :Y1                         124
    :Y2                         178
    :Inverse                    SupervisedByMedOGCC
    :Domain                     GCC
    :Range                      MedO
    :ParentComponent            ProjectEditorImage
)
(Supervise SuperviseGCCCommO
    :X1                         373
    :X2                         381
    :Y1                         124
    :Y2                         174
    :Inverse                    SupervisedByCommOGCC
    :Domain                     GCC
    :Range                      CommO
    :ParentComponent            ProjectEditorImage
```

```
)
(Supervise SuperviseGCCLT_O
    :X1                         373
    :X2                         270
    :Y1                         124
    :Y2                         173
    :Inverse                    SupervisedByLT_OGCC
    :Domain                     GCC
    :Range                      LT_O
    :ParentComponent            ProjectEditorImage
)
(Supervise SuperviseNCCST_O
    :X1                         132
    :X2                         130
    :Y1                         123
    :Y2                         175
    :Inverse                    SupervisedByST_ONCC
    :Domain                     NCC
    :Range                      ST_O
    :ParentComponent            ProjectEditorImage
)
(Supervise SuperviseCJTFACC
    :X1                         370
    :X2                         622
    :Y1                         73
    :Y2                         119
    :Inverse                    SupervisedByACCCJTF
    :Domain                     CJTF
    :Range                      ACC
    :ParentComponent            ProjectEditorImage
)
(Supervise SuperviseCJTFGCC
    :X1                         370
    :X2                         373
    :Y1                         73
    :Y2                         124
    :Inverse                    SupervisedByGCCCJTF
    :Domain                     CJTF
    :Range                      GCC
    :ParentComponent            ProjectEditorImage
)
(Supervise SuperviseCJTFNCC
    :X1                         370
    :X2                         132
    :Y1                         73
    :Y2                         123
    :Inverse                    SupervisedByNCCCJTF
    :Domain                     CJTF
    :Range                      NCC
    :ParentComponent            ProjectEditorImage
)
(Supervise SuperviseExecutiveTeam_PMCJTF
    :X1                         367
    :X2                         370
    :Y1                         21
    :Y2                         73
    :Inverse                    SupervisedByCJTFExecutiveTeam_PM
    :Domain                     ExecutiveTeam_PM
    :Range                      CJTF
    :ParentComponent            ProjectEditorImage
)
(SupervisedBy SupervisedByAT_OACC
    :Inverse                    SuperviseACCAT_O
    :Domain                     AT_O
    :Range                      ACC
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByMedOGCC
    :Inverse                    SuperviseGCCMedO
    :Domain                     MedO
    :Range                      GCC
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByCommOGCC
    :Inverse                    SuperviseGCCCommO
```

```
    :Domain                     CommO
    :Range                      GCC
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByLT_OGCC
    :Inverse                    SuperviseGCCLT_O
    :Domain                     LT_O
    :Range                      GCC
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByST_ONCC
    :Inverse                    SuperviseNCCST_O
    :Domain                     ST_O
    :Range                      NCC
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByACCCJTF
    :Inverse                    SuperviseCJTFACC
    :Domain                     ACC
    :Range                      CJTF
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByGCCCJTF
    :Inverse                    SuperviseCJTFGCC
    :Domain                     GCC
    :Range                      CJTF
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByNCCCJTF
    :Inverse                    SuperviseCJTFNCC
    :Domain                     NCC
    :Range                      CJTF
    :InverseClass               Supervise
)
(SupervisedBy SupervisedByCJTFExecutiveTeam_PM
    :Inverse                    SuperviseExecutiveTeam_PMCJTF
    :Domain                     CJTF
    :Range                      ExecutiveTeam_PM
    :InverseClass               Supervise
)
(ResponsibleFor ResponsibleForMedOMed_ops
    :X1                         512
    :X2                         465
    :Y1                         178
    :Y2                         418
    :Inverse                    ResponsibleByMed_opsMedO
    :Domain                     MedO
    :Range                      Med_ops
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForCommOComm_end
    :X1                         381
    :X2                         540
    :Y1                         174
    :Y2                         469
    :Inverse                    ResponsibleByComm_endCommO
    :Domain                     CommO
    :Range                      Comm_end
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForCommOComm_cont
    :X1                         381
    :X2                         392
    :Y1                         174
    :Y2                         462
    :Inverse                    ResponsibleByComm_contCommO
    :Domain                     CommO
    :Range                      Comm_cont
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForCommOComm_start
    :X1                         381
    :X2                         251
    :Y1                         174
    :Y2                         469
```

```
    :Inverse                    ResponsibleByComm_startCommO
    :Domain                     CommO
    :Range                      Comm_start
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForLT_OLT_end
    :X1                         270
    :X2                         547
    :Y1                         173
    :Y2                         336
    :Inverse                    ResponsibleByLT_endLT_O
    :Domain                     LT_O
    :Range                      LT_end
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForLT_OLT_cont
    :X1                         270
    :X2                         346
    :Y1                         173
    :Y2                         336
    :Inverse                    ResponsibleByLT_contLT_O
    :Domain                     LT_O
    :Range                      LT_cont
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForAT_OAir_ops
    :X1                         622
    :X2                         432
    :Y1                         164
    :Y2                         371
    :Inverse                    ResponsibleByAir_opsAT_O
    :Domain                     AT_O
    :Range                      Air_ops
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForST_OST_end
    :X1                         130
    :X2                         666
    :Y1                         175
    :Y2                         284
    :Inverse                    ResponsibleByST_endST_O
    :Domain                     ST_O
    :Range                      ST_end
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForST_OST_start
    :X1                         130
    :X2                         124
    :Y1                         175
    :Y2                         284
    :Inverse                    ResponsibleByST_startST_O
    :Domain                     ST_O
    :Range                      ST_start
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForExecutiveTeam_PMF_ExecutiveProj
    :X1                         367
    :X2                         741
    :Y1                         21
    :Y2                         283
    :Inverse                    ResponsibleByF_ExecutiveProjExecutiveTeam_PM
    :Domain                     ExecutiveTeam_PM
    :Range                      F_ExecutiveProj
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForExecutiveTeam_PMS_ExecutiveProj
    :X1                         367
    :X2                         43
    :Y1                         21
    :Y2                         284
    :Inverse                    ResponsibleByS_ExecutiveProjExecutiveTeam_PM
    :Domain                     ExecutiveTeam_PM
    :Range                      S_ExecutiveProj
    :ParentComponent            ProjectEditorImage
)
```

```
(ResponsibleFor ResponsibleForST_OST_cont
    :X1                         130
    :X2                         381
    :Y1                         175
    :Y2                         284
    :Inverse                    ResponsibleByST_contST_O
    :Domain                     ST_O
    :Range                      ST_cont
    :ParentComponent            ProjectEditorImage
)
(ResponsibleFor ResponsibleForLT_OLT_start
    :X1                         270
    :X2                         230
    :Y1                         173
    :Y2                         336
    :Inverse                    ResponsibleByLT_startLT_O
    :Domain                     LT_O
    :Range                      LT_start
    :ParentComponent            ProjectEditorImage
)
(ResponsibleBy ResponsibleByMed_opsMedO
    :Inverse                    ResponsibleForMedOMed_ops
    :Domain                     Med_ops
    :Range                      MedO
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByComm_endCommO
    :Inverse                    ResponsibleForCommOComm_end
    :Domain                     Comm_end
    :Range                      CommO
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByComm_contCommO
    :Inverse                    ResponsibleForCommOComm_cont
    :Domain                     Comm_cont
    :Range                      CommO
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByComm_startCommO
    :Inverse                    ResponsibleForCommOComm_start
    :Domain                     Comm_start
    :Range                      CommO
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByLT_endLT_O
    :Inverse                    ResponsibleForLT_OLT_end
    :Domain                     LT_end
    :Range                      LT_O
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByLT_contLT_O
    :Inverse                    ResponsibleForLT_OLT_cont
    :Domain                     LT_cont
    :Range                      LT_O
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByAir_opsAT_O
    :Inverse                    ResponsibleForAT_OAir_ops
    :Domain                     Air_ops
    :Range                      AT_O
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByST_endST_O
    :Inverse                    ResponsibleForST_OST_end
    :Domain                     ST_end
    :Range                      ST_O
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByST_startST_O
    :Inverse                    ResponsibleForST_OST_start
    :Domain                     ST_start
    :Range                      ST_O
    :InverseClass               ResponsibleFor
)
(ResponsibleBy ResponsibleByF_ExecutiveProjExecutiveTeam_PM
```

```
    :Inverse                  ResponsibleForExecutiveTeam_PMF_ExecutiveProj
    :Domain                   F_ExecutiveProj
    :Range                    ExecutiveTeam_PM
    :InverseClass             ResponsibleFor
)
(ResponsibleBy ResponsibleByS_ExecutiveProjExecutiveTeam_PM
    :Inverse                  ResponsibleForExecutiveTeam_PMS_ExecutiveProj
    :Domain                   S_ExecutiveProj
    :Range                    ExecutiveTeam_PM
    :InverseClass             ResponsibleFor
)
(ResponsibleBy ResponsibleByST_contST_O
    :Inverse                  ResponsibleForST_OST_cont
    :Domain                   ST_cont
    :Range                    ST_O
    :InverseClass             ResponsibleFor
)
(ResponsibleBy ResponsibleByLT_startLT_O
    :Inverse                  ResponsibleForLT_OLT_start
    :Domain                   LT_start
    :Range                    LT_O
    :InverseClass             ResponsibleFor
)
(Projects ExecutiveProj
    :LastProjectActivity      F_ExecutiveProj
    :ProjectTeam              ExecutiveTeam
    :FirstProjectActivity     S_ExecutiveProj
    :X                        20
    :Y                        30
    :ProjectActivities        Med_ops Comm_end Comm_cont Comm_start Air_ops LT_end LT_cont
LT_start ST_end ST_cont ST_start F_ExecutiveProj S_ExecutiveProj
    :ProjectApplication               Pretty
    :ProjectName              ExecutiveProj
    :ParentComponent          ProjectEditorImage
)
(Organizations ExecutiveTeam
    :CurrentProject           ExecutiveProj
    :SkillSet                 NotSpecified Amphibious Medical Electrical Flight Logistics
Amphibious Management
    :TeamLeader                       ExecutiveTeam_PM
    :Members                  AT_O MedO CommO LT_O ST_O ACC GCC NCC CJTF ExecutiveTeam_PM
)

%======================= End of File ======================
```

APPENDIX C: VDT OUTPUT RESULTS

```
=========  VDT Output Data File: ========

Project Initialized:                          ExecutiveProj
Project Centralization:                       Medium
Project Formalization:                        Medium
Project Team Matrix Strenght:                 Medium

Project.WorkVolume:                           60000
Project.DurationCalculated:                   18057

Project.VFPinternal:                          0.020000
Project.VFPexternal:                          0.020000
Project Team Experience:                      Medium
Project.InfoExchangeFrequency:                0.020000
Project.NoiseFrequency:                       0.020000
==============================================================================
Actor Initialized:                            AT_O
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor Craft:                                  Flight
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==============================================================================
Actor Initialized:                            MedO
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor Craft:                                  Medical
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==============================================================================
Actor Initialized:                            CommO
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor Craft:                                  Electrical
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==============================================================================
Actor Initialized:                            LT_O
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor Craft:                                  Logistics
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==============================================================================
Actor Initialized:                            ST_O
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor Craft:                                  Amphibous
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==============================================================================
Actor Initialized:                            ACC
Actor Craft:                                  Flight
Actor Skill:                                  Medium
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==============================================================================
Actor Initialized:                            GCC
Actor Craft:                                  Logistics
Actor Skill:                                  Medium
```

```
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==========================================================================
Actor Initialized:                            NCC
Actor Craft:                                  Amphibious
Actor Skill:                                  Medium
Actor Craft:                                  Management
Actor Skill:                                  High
Actor TaskExperience:                         High
Actor Processing Speed:                       1.000000
==========================================================================
Actor Initialized:                            CJTF
Actor Craft:                                  Electrical
Actor Skill:                                  Low
Actor Craft:                                  Flight
Actor Skill:                                  Low
Actor Craft:                                  Logistics
Actor Skill:                                  Low
Actor Craft:                                  Amphibious
Actor Skill:                                  Low
Actor Craft:                                  Medical
Actor Skill:                                  Low
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor TaskExperience:                         Medium
Actor Processing Speed:                       1.000000
==========================================================================
Actor Initialized:                            ExecutiveTeam_PM
Actor Craft:                                  Management
Actor Skill:                                  Medium
Actor TaskExperience:                         Low
Actor Processing Speed:                       1.000000
==========================================================================
Activity Initialized:                         Med_ops
Activity.WorkVolume:                          10560
Activity.TaskNumber:                          22

Activity.EarlyStartTime:                      4297
Activity.DurationPlanned:                     10560
Activity.EarlyFinishTime:                     14857

Activity.SolutionComplexity:                  Medium
Activity.VFPinternal:                         0.020000
Activity.RequirementComplexity:               Medium
Activity.VFPexternal:                         0.020000
Activity.Uncertainty:                         Medium
Activity.InfoExchangeFrequency:               0.019400

Activity.Responsible actor:                   MedO
Activity.ResponsibleActorSpeed:               1.000000
============================================================================
Activity Initialized:                         Comm_end
Activity.WorkVolume:                          960
Activity.TaskNumber:                          10

Activity.EarlyStartTime:                      13417
Activity.DurationPlanned:                     960
Activity.EarlyFinishTime:                     14377

Activity.SolutionComplexity:                  Medium
Activity.VFPinternal:                         0.020000
Activity.RequirementComplexity:               Medium
Activity.VFPexternal:                         0.020000
Activity.Uncertainty:                         Medium
Activity.InfoExchangeFrequency:               0.019400

Activity.Responsible actor:                   CommO
Activity.ResponsibleActorSpeed:               1.000000
============================================================================
Activity Initialized:                         Comm_cont
Activity.WorkVolume:                          9120
Activity.TaskNumber:                          19
```

```
Activity.EarlyStartTime:                    4297
Activity.DurationPlanned:                   9120
Activity.EarlyFinishTime:                   13417

Activity.SolutionComplexity:                Medium
Activity.VFPinternal:                       0.020000
Activity.RequirementComplexity:             Medium
Activity.VFPexternal:                       0.020000
Activity.Uncertainty:                       Medium
Activity.InfoExchangeFrequency:             0.019400

Activity.Responsible actor:                 CommO
Activity.ResponsibleActorSpeed:             1.000000
==========================================================================
Activity Initialized:                       Comm_start
Activity.WorkVolume:                        1440
Activity.TaskNumber:                        10

Activity.EarlyStartTime:                    2857
Activity.DurationPlanned:                   1440
Activity.EarlyFinishTime:                   4297

Activity.SolutionComplexity:                Medium
Activity.VFPinternal:                       0.020000
Activity.RequirementComplexity:             Medium
Activity.VFPexternal:                       0.020000
Activity.Uncertainty:                       Medium
Activity.InfoExchangeFrequency:             0.019400

Activity.Responsible actor:                 CommO
Activity.ResponsibleActorSpeed:             1.000000
==========================================================================
Activity Initialized:                       Air_ops
Activity.WorkVolume:                        10560
Activity.TaskNumber:                        22

Activity.EarlyStartTime:                    4297
Activity.DurationPlanned:                   10560
Activity.EarlyFinishTime:                   14857

Activity.SolutionComplexity:                Medium
Activity.VFPinternal:                       0.020000
Activity.RequirementComplexity:             Medium
Activity.VFPexternal:                       0.020000
Activity.Uncertainty:                       Medium
Activity.InfoExchangeFrequency:             0.019400

Activity.Responsible actor:                 AT_O
Activity.ResponsibleActorSpeed:             1.000000
==========================================================================
Activity Initialized:                       LT_end
Activity.WorkVolume:                        960
Activity.TaskNumber:                        10

Activity.EarlyStartTime:                    14857
Activity.DurationPlanned:                   960
Activity.EarlyFinishTime:                   15817

Activity.SolutionComplexity:                Medium
Activity.VFPinternal:                       0.020000
Activity.RequirementComplexity:             Medium
Activity.VFPexternal:                       0.020000
Activity.Uncertainty:                       Medium
Activity.InfoExchangeFrequency:             0.019400

Activity.Responsible actor:                 LT_O
Activity.ResponsibleActorSpeed:             1.000000
==========================================================================
Activity Initialized:                       LT_cont
Activity.WorkVolume:                        9600
Activity.TaskNumber:                        20

Activity.EarlyStartTime:                    4297
Activity.DurationPlanned:                   9600
Activity.EarlyFinishTime:                   13897
```

```
Activity.SolutionComplexity:                    Medium
Activity.VFPinternal:                           0.020000
Activity.RequirementComplexity:                 Medium
Activity.VFPexternal:                           0.020000
Activity.Uncertainty:                           Medium
Activity.InfoExchangeFrequency:                 0.019400

Activity.Responsible actor:                     LT_O
Activity.ResponsibleActorSpeed:                 1.000000
================================================================================
Activity Initialized:                           LT_start
Activity.WorkVolume:                            1440
Activity.TaskNumber:                            10

Activity.EarlyStartTime:                        2857
Activity.DurationPlanned:                       1440
Activity.EarlyFinishTime:                       4297

Activity.SolutionComplexity:                    Medium
Activity.VFPinternal:                           0.020000
Activity.RequirementComplexity:                 Medium
Activity.VFPexternal:                           0.020000
Activity.Uncertainty:                           Medium
Activity.InfoExchangeFrequency:                 0.019400

Activity.Responsible actor:                     LT_O
Activity.ResponsibleActorSpeed:                 1.000000
================================================================================
Activity Initialized:                           ST_end
Activity.WorkVolume:                            1440
Activity.TaskNumber:                            10

Activity.EarlyStartTime:                        15817
Activity.DurationPlanned:                       1440
Activity.EarlyFinishTime:                       17257

Activity.SolutionComplexity:                    Medium
Activity.VFPinternal:                           0.020000
Activity.RequirementComplexity:                 Medium
Activity.VFPexternal:                           0.020000
Activity.Uncertainty:                           Medium
Activity.InfoExchangeFrequency:                 0.019400

Activity.Responsible actor:                     ST_O
Activity.ResponsibleActorSpeed:                 1.000000
================================================================================
Activity Initialized:                           ST_cont
Activity.WorkVolume:                            11520
Activity.TaskNumber:                            24

Activity.EarlyStartTime:                        2857
Activity.DurationPlanned:                       11520
Activity.EarlyFinishTime:                       14377

Activity.SolutionComplexity:                    Medium
Activity.VFPinternal:                           0.020000
Activity.RequirementComplexity:                 Medium
Activity.VFPexternal:                           0.020000
Activity.Uncertainty:                           Medium
Activity.InfoExchangeFrequency:                 0.019400

Activity.Responsible actor:                     ST_O
Activity.ResponsibleActorSpeed:                 1.000000
================================================================================
Activity Initialized:                           ST_start
Activity.WorkVolume:                            1440
Activity.TaskNumber:                            10

Activity.EarlyStartTime:                        800
Activity.DurationPlanned:                       2057
Activity.EarlyFinishTime:                       2857

Activity.SolutionComplexity:                    Medium
Activity.VFPinternal:                           0.026000
```

```
Activity.RequirementComplexity:                 Medium
Activity.VFPexternal:                           0.026000
Activity.Uncertainty:                           Medium
Activity.InfoExchangeFrequency:                 0.019400

Activity.Responsible actor:                     ST_O
Activity.ResponsibleActorSpeed:                 0.700000
==================================================================================
Activity Initialized:                           F_ExecutiveProj
Activity.WorkVolume:                            480
Activity.TaskNumber:                            10

Activity.EarlyStartTime:                        17257
Activity.DurationPlanned:                       800
Activity.EarlyFinishTime:                       18057

Activity.SolutionComplexity:                    Medium
Activity.VFPinternal:                           0.030000
Activity.RequirementComplexity:                 Medium
Activity.VFPexternal:                           0.030000
Activity.Uncertainty:                           Medium
Activity.InfoExchangeFrequency:                 0.019400

Activity.Responsible actor:                     ExecutiveTeam_PM
Activity.ResponsibleActorSpeed:                 0.600000
==================================================================================
Activity Initialized:                           S_ExecutiveProj
Activity.WorkVolume:                            480
Activity.TaskNumber:                            10

Activity.EarlyStartTime:                        0
Activity.DurationPlanned:                       800
Activity.EarlyFinishTime:                       800

Activity.SolutionComplexity:                    Medium
Activity.VFPinternal:                           0.030000
Activity.RequirementComplexity:                 Medium
Activity.VFPexternal:                           0.030000
Activity.Uncertainty:                           Medium
Activity.InfoExchangeFrequency:                 0.019400

Activity.Responsible actor:                     ExecutiveTeam_PM
Activity.ResponsibleActorSpeed:                 0.600000
==================================================================================
Activity Started:                               S_ExecutiveProj
Activity.StartTime:                             0
Activity.DurationPlanned:                       800
Activity.WorkVolume:                            480
==================================================================================
Activity Completed:                             S_ExecutiveProj
Activity.EarlyStartTime:                        0
Activity.EarlyFinishTime:                       800
Activity.DurationPlanned (Weber Duration):      800

Activity.ActualStartTime:                       0
Activity.ActualFinishTime:                      800
Activity.ActualDuration:                        800

Activity.TaskNumber:                            10
Activity.ResponsibleActor Processing Speed:     0.600000

Activity.WorkVolume (Weber Volume):             480
Activity.ReworkVolume:                          0
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              480
Activity.NumberOfCommunications:                0
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.030000
Final Activity.VFPexternal:                     0.030000
Activity.NumberOfInternalExceptions:            0
Activity.NumberOfExternalExceptions             0
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              0
```

```
Activity.NumberOfLostExceptions (not in VQ)     0
--------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)    1.000000
Activity cost quality ratio (personcost/workdone)     1.666667
Activity value added index ((rwk+coor)/wk)            0.000000
Activity coordination work ratio (comm/rwk)           1.000000
Activity ignored exception ratio (ignored / excep)    1.000000
Activity non-attended comm ratio (nonatt / comm)      1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.301030
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.301030
Activity.VerificationQuality - L2(ign/excep)    0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
================================================================================
Activity Started:                               ST_start
Activity.StartTime:                             800
Activity.DurationPlanned:                       2057
Activity.WorkVolume:                            1440
==================================================================================
Activity Completed:                             ST_start
Activity.EarlyStartTime:                        800
Activity.EarlyFinishTime:                       2857
Activity.DurationPlanned (Weber Duration):      2057

Activity.ActualStartTime:                       800
Activity.ActualFinishTime:                      2850
Activity.ActualDuration:                        2050

Activity.TaskNumber:                            10
Activity.ResponsibleActor Processing Speed:     0.700000

Activity.WorkVolume (Weber Volume):             1440
Activity.ReworkVolume:                          0
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              1440
Activity.NumberOfCommunications:                0
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.026000
Final Activity.VFPexternal:                     0.026000
Activity.NumberOfInternalExceptions:            0
Activity.NumberOfExternalExceptions             0
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              0
Activity.NumberOfLostExceptions (not in VQ)     0
--------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)    0.996597
Activity cost quality ratio (personcost/workdone)     1.423611
Activity value added index ((rwk+coor)/wk)            0.000000
Activity coordination work ratio (comm/rwk)           1.000000
Activity ignored exception ratio (ignored / excep)    1.000000
Activity non-attended comm ratio (nonatt / comm)      1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.301562
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.301030
Activity.VerificationQuality - L2(ign/excep)    0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
================================================================================
Activity Started:                               Comm_start
Activity.StartTime:                             2850
Activity.DurationPlanned:                       1440
Activity.WorkVolume:                            1440
==================================================================================
Activity Started:                               LT_start
Activity.StartTime:                             2850
Activity.DurationPlanned:                       1440
Activity.WorkVolume:                            1440
==================================================================================
Activity Started:                               ST_cont
Activity.StartTime:                             2850
Activity.DurationPlanned:                       11520
Activity.WorkVolume:                            11520
==================================================================================
Activity Completed:                             LT_start
```

```
Activity.EarlyStartTime:                          2850
Activity.EarlyFinishTime:                         4290
Activity.DurationPlanned (Weber Duration):        1440

Activity.ActualStartTime:                         2850
Activity.ActualFinishTime:                        4290
Activity.ActualDuration:                          1440

Activity.TaskNumber:                              10
Activity.ResponsibleActor Processing Speed:       1.000000

Activity.WorkVolume (Weber Volume):               1440
Activity.ReworkVolume:                            0
Activity.CoordinationVolume (infoex only):        0
Total Work: (work, rework, coord.)                1440
Activity.NumberOfCommunications:                  0
ActivityNumberOfNonCompComms:                     0

Final Activity.VFPinternal:                       0.020000
Final Activity.VFPexternal:                       0.020000
Activity.NumberOfInternalExceptions:              0
Activity.NumberOfExternalExceptions               0
Activity.NumberOfReworkedExceptions               0
Activity.NumberOfCorrectedExceptions              0
Activity.NumberOfIgnoredExceptions                0
Activity.NumberOfLostExceptions (not in VQ)       0
-----------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)    1.000000
Activity cost quality ratio (personcost/workdone)     1.000000
Activity value added index ((rwk+coor)/wk)            0.000000
Activity coordination work ratio (comm/rwk)           1.000000
Activity ignored exception ratio (ignored / excep)    1.000000
Activity non-attended comm ratio (nonatt / comm)      1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)      0.301030
Activity.BudgetQuality - L2((rwk+coor)/wk)        0.301030
Activity.VerificationQuality - L2(ign/excep)      0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)      0.301030
=============================================================================
Activity Started:                                 Med_ops
Activity.StartTime:                               4290
Activity.DurationPlanned:                         10560
Activity.WorkVolume:                              10560
===============================================================================
Activity Started:                                 Air_ops
Activity.StartTime:                               4290
Activity.DurationPlanned:                         10560
Activity.WorkVolume:                              10560
===============================================================================
Activity Started:                                 LT_cont
Activity.StartTime:                               4290
Activity.DurationPlanned:                         9600
Activity.WorkVolume:                              9600
===============================================================================
Activity Completed:                               Comm_start
Activity.EarlyStartTime:                          2850
Activity.EarlyFinishTime:                         4290
Activity.DurationPlanned (Weber Duration):        1440

Activity.ActualStartTime:                         2850
Activity.ActualFinishTime:                        4408
Activity.ActualDuration:                          1558

Activity.TaskNumber:                              10
Activity.ResponsibleActor Processing Speed:       1.000000

Activity.WorkVolume (Weber Volume):               1440
Activity.ReworkVolume:                            72
Activity.CoordinationVolume (infoex only):        0
Total Work: (work, rework, coord.)                1512
Activity.NumberOfCommunications:                  0
ActivityNumberOfNonCompComms:                     0

Final Activity.VFPinternal:                       0.020000
Final Activity.VFPexternal:                       0.020000
```

```
Activity.NumberOfInternalExceptions:            1
Activity.NumberOfExternalExceptions             0
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            1
Activity.NumberOfIgnoredExceptions              0
Activity.NumberOfLostExceptions (not in VQ)     0
---------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.081944
Activity cost quality ratio (personcost/workdone)      1.030423
Activity value added index ((rwk+coor)/wk)             0.047619
Activity coordination work ratio (comm/rwk)            0.000000
Activity ignored exception ratio (ignored / excep)     0.500000
Activity non-attended comm ratio (nonatt / comm)       1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.295016
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.290565
Activity.VerificationQuality - L2(ign/excep)    0.176091
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
=================================================================================
Activity Started:                               Comm_cont
Activity.StartTime:                             4408
Activity.DurationPlanned:                       9120
Activity.WorkVolume:                            9120
===================================================================================
Activity Completed:                             LT_cont
Activity.EarlyStartTime:                        4290
Activity.EarlyFinishTime:                       13890
Activity.DurationPlanned (Weber Duration):      9600

Activity.ActualStartTime:                       4290
Activity.ActualFinishTime:                      13936
Activity.ActualDuration:                        9646

Activity.TaskNumber:                            20
Activity.ResponsibleActor Processing Speed:     1.000000

Activity.WorkVolume (Weber Volume):             9600
Activity.ReworkVolume:                          0
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              9600
Activity.NumberOfCommunications:                1
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.020000
Final Activity.VFPexternal:                     0.020000
Activity.NumberOfInternalExceptions:            0
Activity.NumberOfExternalExceptions             1
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              1
Activity.NumberOfLostExceptions (not in VQ)     0
---------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.004792
Activity cost quality ratio (personcost/workdone)      1.004792
Activity value added index ((rwk+coor)/wk)             0.000000
Activity coordination work ratio (comm/rwk)            1.000000
Activity ignored exception ratio (ignored / excep)     1.000000
Activity non-attended comm ratio (nonatt / comm)       0.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.300310
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.301030
Activity.VerificationQuality - L2(ign/excep)    0.000000
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
=================================================================================
Activity Completed:                             Comm_cont
Activity.EarlyStartTime:                        4408
Activity.EarlyFinishTime:                       13528
Activity.DurationPlanned (Weber Duration):      9120

Activity.ActualStartTime:                       4408
Activity.ActualFinishTime:                      14050
Activity.ActualDuration:                        9642

Activity.TaskNumber:                            19
Activity.ResponsibleActor Processing Speed:     1.000000
```

```
Activity.WorkVolume (Weber Volume):            9120
Activity.ReworkVolume:                         480
Activity.CoordinationVolume (infoex only):     0
Total Work: (work, rework, coord.)             9600
Activity.NumberOfCommunications:               0
ActivityNumberOfNonCompComms:                  0

Final Activity.VFPinternal:                    0.020000
Final Activity.VFPexternal:                    0.020000
Activity.NumberOfInternalExceptions:           0
Activity.NumberOfExternalExceptions            1
Activity.NumberOfReworkedExceptions            1
Activity.NumberOfCorrectedExceptions           0
Activity.NumberOfIgnoredExceptions             0
Activity.NumberOfLostExceptions (not in VQ)    0
------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.057237
Activity cost quality ratio (personcost/workdone)      1.004375
Activity value added index ((rwk+coor)/wk)             0.050000
Activity coordination work ratio (comm/rwk)            0.000000
Activity ignored exception ratio (ignored / excep)     0.000000
Activity non-attended comm ratio (nonatt / comm)       1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)   0.292569
Activity.BudgetQuality - L2((rwk+coor)/wk)     0.290035
Activity.VerificationQuality - L2(ign/excep)   0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)   0.301030
==============================================================================
Activity Started:                              Comm_end
Activity.StartTime:                            14050
Activity.DurationPlanned:                      960
Activity.WorkVolume:                           960
================================================================================
Activity Completed:                            ST_cont
Activity.EarlyStartTime:                       2850
Activity.EarlyFinishTime:                      14370
Activity.DurationPlanned (Weber Duration):     11520

Activity.ActualStartTime:                      2850
Activity.ActualFinishTime:                     14370
Activity.ActualDuration:                       11520

Activity.TaskNumber:                           24
Activity.ResponsibleActor Processing Speed:    1.000000

Activity.WorkVolume (Weber Volume):            11520
Activity.ReworkVolume:                         0
Activity.CoordinationVolume (infoex only):     0
Total Work: (work, rework, coord.)             11520
Activity.NumberOfCommunications:               0
ActivityNumberOfNonCompComms:                  0

Final Activity.VFPinternal:                    0.020000
Final Activity.VFPexternal:                    0.020000
Activity.NumberOfInternalExceptions:           0
Activity.NumberOfExternalExceptions            0
Activity.NumberOfReworkedExceptions            0
Activity.NumberOfCorrectedExceptions           0
Activity.NumberOfIgnoredExceptions             0
Activity.NumberOfLostExceptions (not in VQ)    0
------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.000000
Activity cost quality ratio (personcost/workdone)      1.000000
Activity value added index ((rwk+coor)/wk)             0.000000
Activity coordination work ratio (comm/rwk)            1.000000
Activity ignored exception ratio (ignored / excep)     1.000000
Activity non-attended comm ratio (nonatt / comm)       1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)   0.301030
Activity.BudgetQuality - L2((rwk+coor)/wk)     0.301030
Activity.VerificationQuality - L2(ign/excep)   0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)   0.301030
==============================================================================
Activity Completed:                            Med_ops
```

```
Activity.EarlyStartTime:                        4290
Activity.EarlyFinishTime:                       14850
Activity.DurationPlanned (Weber Duration):      10560

Activity.ActualStartTime:                       4290
Activity.ActualFinishTime:                      14850
Activity.ActualDuration:                        10560

Activity.TaskNumber:                            22
Activity.ResponsibleActor Processing Speed:     1.000000

Activity.WorkVolume (Weber Volume):             10560
Activity.ReworkVolume:                          0
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              10560
Activity.NumberOfCommunications:                0
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.020000
Final Activity.VFPexternal:                     0.020000
Activity.NumberOfInternalExceptions:            0
Activity.NumberOfExternalExceptions             0
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              0
Activity.NumberOfLostExceptions (not in VQ)     0
--------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.000000
Activity cost quality ratio (personcost/workdone)      1.000000
Activity value added index ((rwk+coor)/wk)             0.000000
Activity coordination work ratio (comm/rwk)            1.000000
Activity ignored exception ratio (ignored / excep)     1.000000
Activity non-attended comm ratio (nonatt / comm)       1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.301030
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.301030
Activity.VerificationQuality - L2(ign/excep)    0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
================================================================================
Activity Completed:                             Comm_end
Activity.EarlyStartTime:                        14050
Activity.EarlyFinishTime:                       15010
Activity.DurationPlanned (Weber Duration):      960

Activity.ActualStartTime:                       14050
Activity.ActualFinishTime:                      15010
Activity.ActualDuration:                        960

Activity.TaskNumber:                            10
Activity.ResponsibleActor Processing Speed:     1.000000

Activity.WorkVolume (Weber Volume):             960
Activity.ReworkVolume:                          0
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              960
Activity.NumberOfCommunications:                0
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.020000
Final Activity.VFPexternal:                     0.020000
Activity.NumberOfInternalExceptions:            0
Activity.NumberOfExternalExceptions             0
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              0
Activity.NumberOfLostExceptions (not in VQ)     0
--------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.000000
Activity cost quality ratio (personcost/workdone)      1.000000
Activity value added index ((rwk+coor)/wk)             0.000000
Activity coordination work ratio (comm/rwk)            1.000000
Activity ignored exception ratio (ignored / excep)     1.000000
Activity non-attended comm ratio (nonatt / comm)       1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.301030
```

```
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.301030
Activity.VerificationQuality - L2(ign/excep)    0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
================================================================================
Activity Completed:                             Air_ops
Activity.EarlyStartTime:                        4290
Activity.EarlyFinishTime:                       14850
Activity.DurationPlanned (Weber Duration):      10560

Activity.ActualStartTime:                       4290
Activity.ActualFinishTime:                      15391
Activity.ActualDuration:                        11101

Activity.TaskNumber:                            22
Activity.ResponsibleActor Processing Speed:     1.000000

Activity.WorkVolume (Weber Volume):             10560
Activity.ReworkVolume:                          480
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              11040
Activity.NumberOfCommunications:                0
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.020000
Final Activity.VFPexternal:                     0.020000
Activity.NumberOfInternalExceptions:            1
Activity.NumberOfExternalExceptions             1
Activity.NumberOfReworkedExceptions             1
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              1
Activity.NumberOfLostExceptions (not in VQ)     0
--------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)    1.051231
Activity cost quality ratio (personcost/workdone)     1.005525
Activity value added index ((rwk+coor)/wk)            0.043478
Activity coordination work ratio (comm/rwk)           0.000000
Activity ignored exception ratio (ignored / excep)    0.500000
Activity non-attended comm ratio (nonatt / comm)      1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.293046
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.291485
Activity.VerificationQuality - L2(ign/excep)    0.176091
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
================================================================================
Activity Started:                               LT_end
Activity.StartTime:                             15391
Activity.DurationPlanned:                       960
Activity.WorkVolume:                            960
================================================================================
Activity Completed:                             LT_end
Activity.EarlyStartTime:                        15391
Activity.EarlyFinishTime:                       16351
Activity.DurationPlanned (Weber Duration):      960

Activity.ActualStartTime:                       15391
Activity.ActualFinishTime:                      16351
Activity.ActualDuration:                        960

Activity.TaskNumber:                            10
Activity.ResponsibleActor Processing Speed:     1.000000

Activity.WorkVolume (Weber Volume):             960
Activity.ReworkVolume:                          0
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              960
Activity.NumberOfCommunications:                0
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.020000
Final Activity.VFPexternal:                     0.020000
Activity.NumberOfInternalExceptions:            0
Activity.NumberOfExternalExceptions             0
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              0
```

```
Activity.NumberOfLostExceptions (not in VQ)     0
--------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.000000
Activity cost quality ratio (personcost/workdone)      1.000000
Activity value added index ((rwk+coor)/wk)             0.000000
Activity coordination work ratio (comm/rwk)            1.000000
Activity ignored exception ratio (ignored / excep)     1.000000
Activity non-attended comm ratio (nonatt / comm)       1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.301030
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.301030
Activity.VerificationQuality - L2(ign/excep)    0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
================================================================================
Activity Started:                               ST_end
Activity.StartTime:                             16351
Activity.DurationPlanned:                       1440
Activity.WorkVolume:                            1440
==================================================================================
Activity Completed:                             ST_end
Activity.EarlyStartTime:                        16351
Activity.EarlyFinishTime:                       17791
Activity.DurationPlanned (Weber Duration):      1440

Activity.ActualStartTime:                       16351
Activity.ActualFinishTime:                      17791
Activity.ActualDuration:                        1440

Activity.TaskNumber:                            10
Activity.ResponsibleActor Processing Speed:     1.000000

Activity.WorkVolume (Weber Volume):             1440
Activity.ReworkVolume:                          0
Activity.CoordinationVolume (infoex only):      0
Total Work: (work, rework, coord.)              1440
Activity.NumberOfCommunications:                0
ActivityNumberOfNonCompComms:                   0

Final Activity.VFPinternal:                     0.020000
Final Activity.VFPexternal:                     0.020000
Activity.NumberOfInternalExceptions:            0
Activity.NumberOfExternalExceptions             0
Activity.NumberOfReworkedExceptions             0
Activity.NumberOfCorrectedExceptions            0
Activity.NumberOfIgnoredExceptions              0
Activity.NumberOfLostExceptions (not in VQ)     0
--------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)     1.000000
Activity cost quality ratio (personcost/workdone)      1.000000
Activity value added index ((rwk+coor)/wk)             0.000000
Activity coordination work ratio (comm/rwk)            1.000000
Activity ignored exception ratio (ignored / excep)     1.000000
Activity non-attended comm ratio (nonatt / comm)       1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)    0.301030
Activity.BudgetQuality - L2((rwk+coor)/wk)      0.301030
Activity.VerificationQuality - L2(ign/excep)    0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)    0.301030
================================================================================
Activity Started:                               F_ExecutiveProj
Activity.StartTime:                             17791
Activity.DurationPlanned:                       800
Activity.WorkVolume:                            480
==================================================================================
Activity Completed:                             F_ExecutiveProj
Activity.EarlyStartTime:                        17791
Activity.EarlyFinishTime:                       18591
Activity.DurationPlanned (Weber Duration):      800

Activity.ActualStartTime:                       17791
Activity.ActualFinishTime:                      18591
Activity.ActualDuration:                        800

Activity.TaskNumber:                            10
Activity.ResponsibleActor Processing Speed:     0.600000
```

```
Activity.WorkVolume (Weber Volume):            480
Activity.ReworkVolume:                         0
Activity.CoordinationVolume (infoex only):     0
Total Work: (work, rework, coord.)             480
Activity.NumberOfCommunications:               0
ActivityNumberOfNonCompComms:                  0

Final Activity.VFPinternal:                    0.030000
Final Activity.VFPexternal:                    0.030000
Activity.NumberOfInternalExceptions:           0
Activity.NumberOfExternalExceptions            0
Activity.NumberOfReworkedExceptions            0
Activity.NumberOfCorrectedExceptions           0
Activity.NumberOfIgnoredExceptions             0
Activity.NumberOfLostExceptions (not in VQ)    0
---------------------------------------------------------------------------------
Activity schedule quallity ratio (actual/schedule)    1.000000
Activity cost quality ratio (personcost/workdone)     1.666667
Activity value added index ((rwk+coor)/wk)            0.000000
Activity coordination work ratio (comm/rwk)           1.000000
Activity ignored exception ratio (ignored / excep)    1.000000
Activity non-attended comm ratio (nonatt / comm)      1.000000

Activity.ScheduleQuality - L2((act-sch)/sch)   0.301030
Activity.BudgetQuality - L2((rwk+coor)/wk)     0.301030
Activity.VerificationQuality - L2(ign/excep)   0.301030
Activity.CoordinationQuality - L2(ncifx/ifx)   0.301030
=================================================================================
Actor finalized:                               AT_O
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
Actor.NumberOfNonCompComms:                    0
=================================================================================
Actor finalized:                               MedO
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
Actor.NumberOfNonCompComms:                    0
=================================================================================
Actor finalized:                               CommO
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
Actor.NumberOfNonCompComms:                    0
=================================================================================
Actor finalized:                               LT_O
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
Actor.NumberOfNonCompComms:                    0
=================================================================================
Actor finalized:                               ST_O
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
Actor.NumberOfNonCompComms:                    0
=================================================================================
Actor finalized:                               ACC
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
Actor.NumberOfNonCompComms:                    0
=================================================================================
Actor finalized:                               GCC
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
Actor.NumberOfNonCompComms:                    0
=================================================================================
Actor finalized:                               NCC
Actor Processing Speed:                        1.000000
Actor.CoordinationVolume (meets and infoex):   0.000000
Actor.NumberOfNonAttendedMeetings:             0
```

```
Actor.NumberOfNonCompComms:                        0
==================================================================================
Actor finalized:                                   CJTF
Actor Processing Speed:                            1.000000
Actor.CoordinationVolume (meets and infoex):       0.000000
Actor.NumberOfNonAttendedMeetings:                 0
Actor.NumberOfNonCompComms:                        0
==================================================================================
Actor finalized:                                   ExecutiveTeam_PM
Actor Processing Speed:                            0.600000
Actor.CoordinationVolume (meets and infoex):       0.000000
Actor.NumberOfNonAttendedMeetings:                 0
Actor.NumberOfNonCompComms:                        0
==================================================================================
Project.ActualDuration:                            18591
Project.DurationCalculated:                        18057

Project.WorkVolume: (ideal Weber-volume)           60000
Project.ReworkVolume:                              1032
Project.CoordinationVolume: (inf +mts +nse)        0
Total Work: (work, rework, coord., noise)          61032

Project.NumberOfMeetings:                          0
Project.NumberOfNonAttendedMeetings:               0
Project.NumberOfCompletedMeetings:                 0
Project.NumberOfCommunications:                    1
Project.NumberOfNonCompletedCommunications:        1
Project.NumberOfCompletedCommunications:           0
Project.NumberOfNoise:                             5
Project.NumberOfNoiseLookedAt:                     0

Project.NumberOfInternalExceptions:                2
Project.NumberOfExternalExceptions                 3
Project.NumberOfReworkedExceptions                 2
Project.NumberOfCorrectedExceptions                1
Project.NumberOfIgnoredExceptions                  2
Project.NumberOfLostExceptions (not in VQ)         0
Project.NumberOfDefaultDelegations (in ign)        0
Project.NumberOfDependentExceptions (in ext)       1
----------------------------------------------------------------------------------
Project schedule quality ratio (actual/schedule)         1.029573
Project budget quality ratio (personcost/workdone)       1.023676
Project value added work index ((rwk+coor)/wk)           0.017200
Project coordination work ratio (coor / rwk)             0.000000
Project ignored exception ratio (ignored/excep)        0.500000
Project non-attended comm ratio (nonatt/comm)          0.500000

Project.ScheduleQuality - L2((act-sch)/sch)        0.294560
Project.BudgetQuality - L2((rwk+cor+ns)/wk)        0.297279
Project.VerificationQuality - L2(ign/exp)          0.176091
Project.CoordinationQuality - L2(noatt/att)        0.176091
============================================================
```

LIST OF REFERENCES

-, C2 Warfare: Joint Command and Control Warfare Staff and Operations Course Student Text, Armed Forces Staff College, 1996.

-, Chairman of the Joint Chiefs of Staff, *Memorandum of Policy 30* (CJCS MOP 30), Subject: Command and Control Warfare, Washington, D.C., March 8, 1993.

-, *Command and Control*, C4I Division, Headquarters, U.S. Marine Corps, circa. 1995.

-, *Conduct of the Persian Gulf War*, Secretary of Defenses final report to Congress, 1992.

-, Office of the Secretary of Defense, Department of Defense Directive (Draft) S-3600.1, Washington, D.C., 1996.

Burton, R. M., Obel, B., *Strategic Organizational Diagnosis and Design: Developing Theory for Application*, Kluwer Academic Publishers, 1995.

Carley, Kathleen M., Computational and Mathematical Organization Theory: Perspective and Directions, *Computation and Mathematical Organization Theory 1:1*, 1995, Kluwer Academic Publishers, pp. 39-56.

Hafner, Katie, Lyon, Matthew, *Where Wizards Stay up Late: The Origins of the Internet*, Simon and Schuster, New York, 1996.

James, S. D., *Thinking Strategically about Information-Based Conflict: Developing an Analytical Approach to Operational Measures of Effectiveness*, Naval Postgraduate School, 1996.

Jin, Yan and Levitt, Raymond E., The Virtual Design Team: A Computational Model of Project Organizations, Stanford University, 1995.

Levitt, Raymond E., Christiansen, Tore R., Cohen, Geoff P., Jin, Yan, Kunz, John C., Nass, Clifford I., *The Virtual Design Team: A Computational Simulation Model of Project Organizations*, Stanford University, 1995.

Sessions, S. D., & Jones, C. R., *Coalition Command and Control*, Naval Postgraduate School, 1996.

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